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ABSTRACT

This report, the third in a series from the spring 1998 national survey, "Teaching, Learning, and Computing," focuses on how teachers have incorporated computers into their instructional practices. The study is comprised of completed questionnaire responses from teachers, principals, and school technology coordinators from 1,616 schools. Part 1 discusses teacher-directed student use of computers, including basic descriptive statistics, access to classroom computers, and computer platforms used by students. The extent and variety of software used and teachers' objectives for use are addressed in part 2, including types of software used, software that teachers judge as most valuable for students, patterns of software use, objectives for computer use, and student computer use for school work on their own time. Part 3 considers teacher computer expertise and professional use, including teacher professional use of software, and teacher self-reported expertise with computers. It was found that teachers who are the most technically knowledgeable about computers are the ones most likely to have students use computers in varied and complicated ways. At any level, the cluster of teachers strong in most aspects of computer use is small (5% of elementary school teachers, 4% of middle school teachers, and 13% of high school teachers). Although small in numbers, these teachers constitute the standard for instructional computer use, and their numbers are likely to increase in the near future. Data are presented in 24 tables throughout the report. Supplementary tables and a summary of study methodology are appended. (MES)

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Henry J. Becker
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Teaching, Learning, and Computing: 1998 National Survey

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Center for Research on Information Technology and Organizations
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And

University of Minnesota

November, 1999

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EXECUTIVE SUMMARY

Teachers' access to personal computers at school and at home has increased to the point where, by 1998, 93% of teachers in grades 4-12 were using computers as a part of their professional lives. A majority of teachers now have a computer in their classroom and nearly 80% have one at home. Most teachers find computers useful for preparing handouts for lessons, recording student grades, and doing other work of knowledge professionals. However, what is most significant about teachers' involvement with computers is not their own professional use, but the role teachers play in directing students' use of this still-maturing and rapidly changing technology. This report, the 3rd in a series from the Spring, 1998 national survey, *Teaching, Learning, and Computing: 1998*, focuses on how teachers have incorporated computers into their instructional practices.

While the majority of American teachers (71%) assign computer work to students at least occasionally, only about one third do so on a regular basis. Apart from computer teachers, business education and vocational teachers are more likely than teachers of other subjects to use computers regularly with students – i.e. it is quite typical for their students to use computers twenty times or more during the school year. Aside from these more likely candidates for frequent computer use, English and elementary teachers are also more apt to use computers on a regular basis with their students. In fact 30% of English teachers and 43% of elementary teachers (those who teach the traditional self-contained class) assign computer work frequently while only about one in six science teachers, one in eight math teachers, and one in ten social studies and fine arts teachers do. Thus, much of students' computer education experiences occur outside of academic courses, particularly at the high school level, when students are more likely than at other grade levels to be taking computer, business, or vocational courses. At lower grade levels, however, when students have less opportunity to take these elective courses, their computer experience more likely occurs in academic classes. For example, at the middle school level, 30% of students' experience using computers takes place in English classes.

Regular use of computers with students is highly dependent on access to computers. TLC data show that teachers who assign computer work to students use rooms with many computers in them. However, besides computer teachers and business education teachers, most other teachers have relatively few computers compared to the number of students in their classroom. In fact, only 14% of English and 13% of math teachers have a decent ratio of one computer for every four students. Those who don't have this level of access in the classroom must therefore make use of shared spaces, like computers labs. However, access to several computers in a classroom proves to be a more suitable setting for a great deal of school-based computer use than does an even greater number in a computer lab, particularly for academic secondary teachers. Our data shows that computer-assigning academic secondary teachers who have at least one computer in their classroom for every four students are more than 3 times as likely to have students use computers on a regular basis than those who don't have classroom access and use computers in labs (62% are frequent users compared to 18% of those who have no computers in their classroom and use labs for their students' computer work).

Except for elementary teachers, who still make frequent use of game and drill software, skills-practice through computers has become much less common than other uses of computers. In particular, word processing is used by students of 50% of all teachers in the study (grade 4-12 teachers) and CD-ROM reference software is used by 36% of all teachers. As discussed more extensively in Report 1 in this series,[1] roughly 30% of all teachers have students use the World Wide Web. Relatively few teachers make use of more analytic and project-oriented software, particularly on a frequent basis. For example,

[1] Henry Jay Becker, Internet Use by Teachers: Conditions of Professional Use and Teacher-Directed Student Use. Report #1, Teaching, Learning, and Computing: 1998 National Survey. University of California, Irvine. February, 1999. http://www.crito.uci.edu/TLC/FINDINGS/internet-use/startpage.htm

only 4% of English teachers have students use presentation software on at least 10 occasions, and only 5% of science teachers had students use simulation or modeling software that often. As for spreadsheet and database programs, only 7% of vocational education teachers had students use that type of software 10 times. Math teachers, along with foreign language teachers, are among the least likely to be making computers a regular part of their instructional practice. They are the only secondary subject category where skills-practice-games is the most common type of software used, and even then, only one-quarter of math teachers do that.

The software teachers most often name as their most valuable programs for student use are general office applications such as ClarisWorks and Microsoft Works and web browsers such as Netscape. In addition, certain individual software titles attract noticeable numbers of teachers in specific fields: Accelerated Reader and Hyperstudio among elementary and some middle grades teachers, Geometer's Sketchpad in math, and AutoCAD in Vocational Education, to name the most-often mentioned ones.

We found it was useful to classify teachers according to the pattern of different types of software they had students use. Several distinct patterns of use were uncovered at each school level--some emphasizing frequent use of a single type of software, others involving diverse types of software. However, the most extensive and diverse software use practices taken together involve only a small percentage of teachers, on the order of 10 to 15% in total, and several of those clusters are dominated by computer and business education teachers. However, several other "clusters" do contain disproportionate numbers of English teachers as well as secondary teachers of mixed academic subjects (a special category of teachers).

Just as skill and drill games are no longer the most commonly used software applications, objectives for computer use have extended beyond just "learning computer skills" or using computer games for the limited purpose of mastering content. In fact, "finding out about ideas and information" was the most commonly reported objective followed by students "expressing themselves in writing."

Teachers' objectives for students' computer use do vary by the subjects they teach. Social studies and teachers of mixed academic subjects are more interested in students finding out about ideas than are others while English and elementary teachers are more likely to be interested in students expressing themselves in writing. In contrast, math, computer, and business teachers reported more traditional objectives. They are more likely to select mastering skills and improving computer skills. Of course teachers interested in skill-related objectives are more likely to use game software, but, they tend to use that type of software almost exclusively while teachers holding other objectives tend to use a greater variety of software. For example, those interested in having students find out about ideas and information not only have students use CD-ROM reference software, and the World Wide Web, two applications naturally associated with information retrieval, but they were also likely to have their students use word processing software.

Aside from in-class computer work, TLC asked teachers how often their students worked on computer assignments for that class *outside* of class time. This survey question proved quite revealing in distinguishing between teachers who see computers as tools that enable students to do productive work versus teachers who see computers in "skills" terms (either as a means for mastering basic literacy skills or as a new set of technology skills). We found that teachers more likely to have students do computer work on their *own* time (e.g. before or after class) were more likely to select four main objectives for student computer use: "presenting information to an audience," "improving their writing," "communicating with other people," and "finding out about ideas and information." Those objectives are all about building competencies for skill-integrating productive work. The teachers who were *less* likely to report that their students used computers to do classwork outside of class time were more likely select as their top objectives reinforcing skills just taught, remediation of skills, and learning to work

independently. The fact that their students don't use computers outside of class is a consequence of how those teachers have defined the purpose of computers: isolated, decontextualized "learning."

A teacher's skill in using computers certainly has an impact on how they use computers, and in how they see their role to begin with. TLC asked teachers to rate themselves on how well they knew how to perform certain tasks ranging from basic ones such as displaying the directory of a disk to more complex activities such as developing a multimedia document. Teachers were also asked to self-evaluate their experience and expertise on different computer platforms. Although the majority of teachers felt they were "very experienced" on at least one platform, only 3% felt that they were "expert" on multiple platforms (e.g., Macintosh AND Windows). We found that the greater their platform expertise and the greater number of computer-related tasks teachers reported they could do, the more substantially they used computers for their own *professional* purposes. Teacher computer skill level was also associated with more frequent assignment of computer work to students, but this relationship was not as strong as the one for teachers' own professional use of computers. We also found that the more computer-skilled teachers were, the more likely their primary objective for having students use computers had to do with students presenting material, communicating electronically, and analyzing information. Teachers simply interested in having students use computers for purposes of remediating skills were those with lower levels of computer expertise.

Finally, we combined information about teacher expertise, teacher professional use, and objectives for student computer use most closely associated with higher levels of student use outside of class time to identify those clusters of teachers who are strongest on all those dimensions. At the elementary level, we identified two clusters of teachers who are strong in these respects (although together involving only 5% of all upper-elementary teachers). Both emphasized student production of multimedia and a majority of both groups named one program, Hyperstudio, as their most valuable software. At the middle grades, two clusters also appeared notable (4% of middle grades teachers), and these classes emphasized word processing and use of the World Wide Web, along with some use of electronic mail (in one cluster) and presentation and multimedia software as well. At the high school level, five clusters of teachers had relatively high levels of computer expertise (13% of high school teachers), but only one of those clusters (2% of high school teachers) seemed outstanding in terms of having objectives for student computer use that translated into high levels of out-of-class involvement in computer work for the class. Those classes, primarily English, social studies, and computer classes, used an array of software going beyond word processing, Web browsing, and CD-ROM use, to include presentation software (Powerpoint was second-only to Netscape as those teachers' most valued software) and other graphically-oriented programs. Though teachers in these clusters constitute only a minority of teachers, due to their exemplary use of computers with students, they deserve even closer examination.

GUIDE TO DATA TABLES

A "Summary of Study Methodology" is attached as Appendix B to this report, and provides a more complete background to the design of the TLC survey. The following are some additional notes, particularly oriented towards interpreting the data tables:

Although the data tables are based on weighted cases (weights inverse to the probability of selection), raw N's (number of teachers responding) accompany most tables. Those numbers provide a rough sense of the sampling reliability of a cell's mean or a set of row or column percentages without the additional complexity of displaying standard deviations and significance levels and/or effect sizes for all of the many comparisons that might be made with a table's statistics. The comparisons are shown largely to suggest and explore propositions rather than to test specific hypotheses. Moreover, analyses are bi-variate or involve at most three variables; future research that simultaneously incorporates multiple predictor variables to test propositions about explanation of variance will include tests of statistical significance as appropriate.

Generally speaking, the sample population for any given table is one of several types: (a) all teachers in the probability sample (see Appendix B); (b) all teachers in both the probability and purposive samples; (c) teachers (in either (a) or (b)) who assigned computer work to any of their classes; or (d) teachers who assigned computer work to a specific class which they selected as the one in which they felt they most successfully accomplished their teaching objectives. The latter two groups are both referred to as "computer-assigning teachers." The sample population for each table is described next to the term "universe," under each table.

A number of tables divide teachers by the subject-matter of the classes that they teach. Middle and high school teachers are designated by the subject they teach to more than one-half of their teaching load. Teachers who teach two subjects equally or a range of subjects are classified as either "mixed academic secondary" or "other applied secondary," depending on the nature of their courses. Tables that are based on a single class—the teacher's specifically selected class—have similar categories except that instead of "mixed academic," the phrase "misc. academic" is used. Elementary grade teachers (grades 4 through 6 in K-6 or K-5 schools as well as grades 4 and 5 in schools that go above grade 6) are broken out into only two categories: those who teach a single self-contained class (same students, all subjects), and those who teach a single subject or some combination of multiple classes and multiple subjects.

PART I. TEACHER-DIRECTED STUDENT USE OF COMPUTERS

BASIC DESCRIPTIVE STATISTICS

By the 1997-98 school year, almost three-quarters of American teachers (71% among teachers of grades 4-12) had students use computers during class time at some point during the school year. In some cases, teachers used computers with certain classes but not others. However, 60% of all teachers had students use computers in the single class that we sampled for further study: the class where they felt most satisfied with their teaching—"where you accomplish your teaching goals most often."

Teachers of some subjects[2] and school levels are less likely to have students use computers than others. In particular, teachers of secondary academic subjects (math, social studies and foreign language, in particular) are less likely to have their students use computers than are elementary teachers of self-contained classes or teachers of business and vocational subjects. Overall, about one-half of math teachers (49%), slightly more social studies teachers (56%), two-thirds (66%) of science teachers, and three-fourths (75%) of English teachers reported some use of computers by students during at least one of the classes they taught that year (compared to 79% of vocational education teachers, 87% of elementary teachers of self-contained classes, and 93% of business education teachers. (See first two data columns in Table 1.)[3]

TABLE 1: TEACHERS' COMPUTER USE PRACTICE BY SUBJECT & LEVEL

Subject and Level Taught (Where level not indicated: secondary, i.e., middle or high school grades)	% that have students use computers in the selected class*	% that have students use computers in other classes, but not that class	% that use computers only for professional activities	% that do not use computers but have in the past	% that never used computers in teaching or other activities	Total (N)
Elementary Self-Contained	73	15	9	2	2	100 (386)
Elementary Other	64	14	14	4	5	100 (160)
English	65	10	20	4	1	100 (326)
Science	60	6	30	3	1	100 (312)
Social Studies	50	6	32	8	4	100 (212)
Foreign Language	38	17	38	0	8	100 (49)
Math	37	12	38	7	6	100 (262)
Mixed Academic Secondary	72	15	11	1	1	100 (135)
Computer	94	4	1	0	0	100 (102)
Business	82	11	0	4	3	100 (79)
Vocational	73	6	20	1	0	100 (76)
Fine Arts	36	17	39	4	4	100 (72)
Other Applied Secondary	40	11	43	2	5	100 (57)
All Teachers	60	11	23	4	3	100 (2,228)

Universe: All teachers in probability sample (grades 4-12, not including physical education).
* Class named by teacher as the one in which teaching goals are most often accomplished.

[2] Defined as the subject-matter of the majority of the classes they taught. If a teacher taught different subjects to different classes, they were coded as "mixed academic" or "other applied," depending on the nature of the subjects taught. If they taught all subjects to a single class, they were coded as teaching a "self-contained" class.

[3] In all tables, (N) refers to the actual number of teachers responding in that category. Percentages and means however, reflect weights based on the inverse of the probability that each teacher has selected for the sample. Two different weights were used, depending on whether the table refers to data from only the national probability sample of schools (as in Table 1) or from teachers in both the national probability sample and the two categories of purposive samples of schools ("educational reform" and "high-end technology") that comprised 45% of the total set of schools studied. For further information about the sample and data collection methodology, see Appendix B at the end of this document.

Nearly all teachers, including *most* of those who do not assign computer work, are computer users themselves. For eleven of the thirteen subject-level categories studied (all except secondary math and social studies), more than 90% of teachers either had their students use computers or used them for their own professional needs.

Location of Computer Use

A majority of teachers whose students use computers make use of computers in their own classroom (nearly 80% at the elementary level and about 60% in middle and high schools). However, at each school level only a minority of computer-assigning teachers uses their classroom as the *sole primary* location of computer use during class time. Nearly 40% of elementary computer-assigning teachers (and 20% of secondary teachers) have their students do much of their computer work *both* in the classroom and in another location. In most cases, that other location is a "computer lab," but sometimes the library or media center serves that function too. Moreover, one-fifth of computer-assigning elementary teachers and two-fifths of those at secondary levels make the computer lab (or other non-classroom location) the primary place where their students do computer work during class time.

There are major differences between teachers of different subjects in where their students use computers during class time. Those differences are discussed below under the topic of "access to classroom computers."

Frequent Use by Students

In Table 1, teachers were counted as "computer-assigning teachers" even if they had students use computers only rarely or occasionally. However, unless teachers assign computer tasks frequently, important consequences are not likely to occur. Table 2 draws attention to those classes[4] where teachers reported that the typical student used computers *on more than 20 class days* during the school year.

Using that criterion for applying the term "frequent student computer use," we see that, as of Spring, 1998, only one-fourth of all 4^{th}-12^{th} grade teachers (27%) gave students a frequent opportunity to use computers during class time. Variations across teachers of different subject-level categories are even greater than for our measure of "any student computer use." The left-hand side of Table 2 shows that the vast majority of secondary teachers of computer classes (80%) and two-thirds of secondary business education teachers (70%) had the students in their selected class use computers on more than 20 occasions. Also, a substantial fraction of vocational teachers (42%), elementary teachers of self-contained classes (43%), and secondary English teachers (24%) had their students use computers frequently. At the other extreme, only 11 to 17 percent of secondary math, social studies and science teachers frequently assigned computer work, as did fewer than one in ten fine arts teachers.

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[4] In Table 2, we focus on computer use in one class taught by each sampled teacher, which we call the 'selected' class. This is the class where the teacher felt most accomplished in teaching. In this table, the teachers themselves are defined not in terms of the subject that they taught most often, but by which subject they taught that particular class.

TABLE 2: FREQUENT STUDENT COMPUTER USE, BY SUBJECT & LEVEL

Subject and Level Taught	% of teachers giving frequent computer assignments (students used 20+ times)	Distribution of all frequent computer-assigning teachers by subject, by level taught			
		Elementary grades (4+)	Middle school grades	High school grades	Total
Computer	80	0	16	16	10
Business	70	0	4	19	8
Vocational	42	0	3	13	5
Elementary Self-Contained	43	78	0	0	28
Mixed Academic Secondary	43	0	10	5	5
English	24	0	28	19	15
Elementary Other	26	22	0	0	8
Science	17	0	13	12	8
Other Applied Secondary	13	0	3	3	2
Math	11	0	17	4	7
Social Studies	12	0	5	5	3
Fine Arts	9	0	1	3	1
Foreign Language	0	0	0	2	1
All Teachers (N)	27	100 (523)	100 (403)	100 (412)	100 (1,338)

Universe for first column: All teachers in probability sample. For N's for this column, see Table 1.
Universe for remaining columns: Probability sample; teachers who assign computer work in any class they teach.

Rather than asking what percent of *teachers* use computers frequently with students, it is also helpful to examine computer use from a student experience perspective; that is, "In what classes do students get their more intensive computer experiences?" The last three columns of Table 2 present the fraction of all "frequent use experiences" that occur in classes of different subjects, for elementary, middle, and high school levels respectively. The vast majority of frequent use at the elementary level occurs in the self-contained classes (78%), but at the secondary levels, the breakdown of use by subject reveals some interesting patterns.

In secondary schools as a whole, frequent student computer use occurs in English classes more often than in any other subject—including computer classes. That is because, at any one time, only a modest fraction of students are taking computer classes, but nearly every student is taking English. English class settings for frequent computer use are particularly common at the middle school level, where the second-most common venue, mathematics, occurs less than two-thirds as often (17% vs. 28%).

At the high school level, frequent computer use occurs as often in business education classes as in English (each had 19% of all frequent use experiences), with computer classes third (16%). Overall, a majority of high schoolers' frequent computer experiences occur *outside of the academic subjects*. At the high school level, as students move closer toward the working world, they are more likely to take specialized classes that teach the application of computers to adult-related tasks.

ACCESS TO CLASSROOM COMPUTERS

Although subject-matter responsibilities clearly affect teachers' opinions of the relevance of computers to their instructional agenda, frequent use of computers is much more likely when teachers have convenient access to a substantial number of them and when that access is convenient. Moreover, the effects of access to computers and subject-matter responsibilities on frequency of use are difficult to disentangle because access and subject-matter are related as well. That is, teachers of some subjects are much more likely to have many computers available in their own classroom than are teachers of other subjects.

Computer-Student Ratios in Classrooms

In particular, more than 80% of secondary teachers of computer education classes, two-thirds (67%) of business education teachers and 23% of vocational education teachers had a ratio of computers-to-students in their classroom of at least 1-to-4; that is, if they had 24 students, they had at least 6 computers. In comparison, that density of classroom computer access prevailed for only one in ten academic secondary teachers and only 5% of elementary teachers. Only 7% of science teachers had a 1:4 ratio of computers to students in their classroom, only 2% of the social studies teachers did, and none of the 30 foreign language teachers studied for the analysis in Table 3 had that many computers in their classroom. In fact, among the secondary academic subjects, for only English and science did a majority of teachers have *any* computers in their classroom. At the elementary level, a small number of computers, typically one or two, were present in the classrooms of most teachers, whether teachers of self-contained classes or subject specialists.

TABLE 3: CLASSROOM COMPUTER-STUDENT RATIO BY SUBJECT & LEVEL

	Classroom Computer-to-Student Ratio				
Subject and Level Taught	% with at least 1 per 4 students	% with under 1 to 4	% with no computers	Total	(N)
Computer	82	3	15	100	(50)
Business	67	7	27	100	(31)
Vocational	23	54	23	100	(43)
Mixed Academic Secondary	22	24	53	100	(40)
English	14	41	46	100	(167)
Math	13	16	72	100	(149)
Other Applied Secondary	12	19	69	100	(32)
Elementary Other	11	59	30	100	(79)
Science	7	47	46	100	(157)
Fine Arts	6	22	72	100	(38)
Elementary Self-Contained	3	68	30	100	(192)
Social Studies	2	31	67	100	(93)
Foreign Language	0	16	84	100	(30)
All Teachers	13	39	49	100	(1,101)

Universe: Probability sample; questionnaire versions 1 and 2.

Number of Classroom Computers Needed For Frequent Use

Not surprisingly, for every subject-level combination examined, the more computers present in the classroom, the more likely that a teacher will have students use them frequently. This holds true even among just the computer-assigning teachers, and it also holds true even when including classes that use computer labs or media centers as well—the more computers in the *classroom*, the greater the level of student use. For elementary teachers and for secondary English teachers, even small numbers of computers in their own classroom lead half of them to use computers regularly with students. For most other subjects, there has to be a substantial number of computers present (in our analysis, a 1:4 ratio of computers to students) for a majority of computer-assigning teachers to make computer activities a regular and frequent component of their classroom practice. But when that happens, a majority of secondary social studies, science, and math computer-assigning teachers become frequent computer-assigning teachers.

Table 4 presents these findings.[5] For example, among science and social studies teachers who do assign computer work at least sometimes, only 9% assign work frequently (i.e., more than 20 times during the year) if they have *no* computers at all in their classroom; 18% assign frequent computer work if they have some computers in their classroom but fewer than one for every four students. However, among those secondary science and social studies teachers with at least 1 computer per 4 students, a *majority* of them assigned computer work frequently (53% of the 50 teachers studied, as shown in the second row of Table 4). Differences as dramatic are shown in Table 4 for mathematics teachers and similar differences, though less dramatic, apply to English teachers and to teachers in applied secondary subjects.

In contrast, among elementary teachers, although having *some* computers in the classroom makes frequent computer use more likely, having a 1:4 ratio of computers-to-students in the classroom does not appear to be as necessary a condition of frequent use.[6] Perhaps this is because in most elementary classes, teachers see their students for much longer periods of time. As a result, they can use that extended time to orchestrate computer use among many students, even when they have only a handful of computers present. Another reason may be that given the ways that most elementary level teachers currently use computers (see Part II of this report) the most significant computer use may occur in computer labs away from the classroom, so the number present in the classroom may not make so much of a difference in frequency of use.

TABLE 4: PERCENT OF COMPUTER-ASSIGNING TEACHERS WHOSE STUDENTS USE COMPUTERS FREQUENTLY, BY CLASSROOM COMPUTER-STUDENT RATIO, BY SUBJECT & LEVEL

	CLASSROOM COMPUTER-TO-STUDENT RATIO							
	At least 1 per 4 students		Under 1 to 4		No computers		Total	
Subject and Level Taught	% freq. user	(N)	% freq. user	(N)	% freq. user	(N)	% freq. user	(N)
English	82	(31)	51	(135)	16	(57)	48	(223)
Social Studies-Science	53	(50)	18	(211)	9	(75)	21	(336)
Math	89	(29)	14	(73)	7	(57)	23	(159)
Comp-Bus-Voc	87	(115)	40	(34)	66	(29)	74	(178)
All Other Secondary	71	(33)	31	(72)	17	(56)	32	(161)
Elementary	67	(61)	55	(332)	34	(81)	53	(474)
All computer-assigning teachers	77	(319)	37	(857)	21	(355)	41	(1,531)

Universe: Probability and purposive samples; questionnaire versions 1 & 2; teachers who assign computer work in any class they teach.

Computer Access in Labs and Media Centers versus Classrooms

Teachers without a sufficient number of computers in their classroom generally have access to shared school or department facilities—specialized computer laboratories or more general resource areas such as a library or media center. Typically, computer labs and libraries accommodate many more students at one time than computer-present classrooms do. (The typical lab has 21 computers; the typical classroom with any computers at all has only 2 of them.) Thus, teachers with only one or two classroom computers may have their students use computers in a lab instead of using the limited number in the classroom. Indeed, most teachers who give computer-based assignments do make some use of a computer lab or media center, and 46% of teachers who have at least one computer in their classroom report using shared

[5] In Table 4, subject categories were collapsed and teachers from the purposive samples were included in order that each cell in the table was based on at least 30 (actually 29) cases.

[6] The difference in the percentage of frequent users among computer-assigning teachers is only 12 percentage points between elementary teachers with at least one computer in their classroom, but fewer than one-per-four students (55%); and elementary teachers with a better computer-student ratio (67%).

facilities as much as their classroom computers anyway. Even among teachers who have their students use computers only sometimes (i.e., not frequently), three-fourths of them do so in a room where there is *at least one computer for every four students* (most often a computer lab or media center). This seems to be the case across most subjects.

In sum, most teachers who use computers with their students, particularly at the secondary levels, use them in *some* room where there are a substantial number of computers present. If they don't have a large number in their classroom, they will use a computer lab (but they will use computers less often than if they had them in their classroom). If they don't have enough computers in any location, they just won't have students use them at all.

Which Promotes More Frequent Use: High Computer Density in Labs or Convenience of Classroom Location?

How many computers in a classroom provide sufficient convenience and independence for teachers that those advantages outweigh the value of the larger number of computers in a shared computer lab? Under which condition is frequent computer use more likely to take place—where there are many computers available in a lab or where there are a reasonable number in a classroom? Table 5 provides some interesting contrasts. It shows that for secondary computer-assigning teachers in particular, both for teachers of academic subjects and other subjects that *don't require* computer use, a higher proportion of teachers with five or more computers in their room give frequent computer assignments than those whose students use computer labs with 15 or more computers in them—three times as many computers.

TABLE 5: PERCENT OF COMPUTER-ASSIGNING TEACHERS WHO ASSIGN COMPUTER WORK FREQUENTLY, BY SUBJECT & LEVEL, BY NUMBER OF COMPUTERS IN CLASSROOM AND LAB

	Number of computers in classroom and lab (or other outside location)			
Subject and Level Taught	None in classroom; 15+ in lab	1-4 in classroom; 15+ in lab	5 or more in classroom (usually 5-8)**	All other (0-4 in class; under 15 outside if available)
Elementary	*	61% (200)	75% (99)	47% (123)
Academic Secondary	18% (82)	32% (342)	62% (164)	22% (132)
Computer and Business	*	*	88% (99)	*
Other including Fine Arts and Vocational	*	32% (36)	64% (44)	30% (58)

Universe: Probability and purposive samples; questionnaire versions 1 & 2; teachers who used computers with their selected class.
* Fewer than 20 cases
** Includes both teachers who use labs and those who don't

Thus, secondary teachers with just five or six computers in their classroom are much more likely to use computers on a regular basis than are teachers of the same subjects who make use of computer labs with substantially more computers in them but who have few, if any, computers in their own room. This may seem counter-intuitive since being in a lab with three times as many computers as these classrooms would seem to give individual students more opportunities to use computers. However, it seems that the computer's value in most secondary classes is not for concentrated whole-class use on a scheduled basis, but as a resource available for particular groups of students *when needed* to find, analyze, or communicate information.

This analysis does not take into account the economies that centralized placement of computers involve. In other words, if all of a school's two dozen academic subject-matter teachers had five computers in their classrooms instead of sharing 30 computers in a computer lab, four times as many computers in total would be required. Instead, what we are examining is the relative likelihood that students will receive a substantial computer experience during instructional time. If centralized placement of computers does not result in students getting a substantial experience with using computers to pursue academic goals, such

aggregation may not be efficient. We found that particularly in secondary schools with their short-duration class periods, students are much more likely to have a frequent computer experience when it occurs primarily in the teacher's own classroom in which a 1:4 ratio of computers to students prevails.

COMPUTER PLATFORMS USED BY STUDENTS

During most the 1990's, American schools followed the pattern of American businesses and families of moving more of students' computer work onto computers running the Windows operating system. This pattern was not uniform, however, and certain types of teachers have their students use computers with the Apple Macintosh operating system. Although the two operating systems have strong similarities, they do differ in the number of discrete instructional products available, in the learning time required to become expert in their use, and in other ways.

Table 6 shows the primary computer platform employed by the computer-assigning teachers in the study. Windows' dominance is clearest among secondary computer education teachers, business education teachers, and vocational education teachers—the groups that are most likely to assign computer work to students frequently and who have access to higher ratios of computers to students. Macintosh computers are used by almost three-quarters of fine arts teachers, and that platform also dominates the arrangements where students of "miscellaneous-subjects" academic teachers use computers in secondary schools. Among elementary school teachers, those who teach specialized programs, rather than a self-contained class, are more likely than are other elementary computer-assigning teachers to have their students use Macintosh computers.

TABLE 6: PERCENT OF COMPUTER-ASSIGNING TEACHERS WHOSE STUDENTS USE EACH COMPUTER OPERATING SYSTEM PLATFORM IN THE SCHOOL ROOM WHERE THEY USE COMPUTERS

	Percent Whose Students Use...					
	Macintosh	Windows	Apple II	Mixed*	Total	(N)
Elementary self-contained	35	23	8	34	100	(311)
Elementary other	59	32	2	8	100	(98)
English	46	41	1	12	100	(180)
Science	34	54	0	12	100	(199)
Math	30	48	4	19	100	(113)
Social Studies	21	64	5	10	100	(88)
Foreign Language	56	44	0	0	100	(13)
Miscellaneous Academic Sec.	45	36	3	16	100	(51)
Computers	12	76	3	9	100	(80)
Business	8	75	8	8	100	(34)
Vocational	17	79	0	4	100	(40)
Fine Arts	70	20	0	10	100	(27)
Other Applied Secondary	7	93	0	0	100	(27)
Elementary	42	25	6	26	100	(408)
Middle School	42	49	2	8	100	(447)
High School	23	60	2	15	100	(406)
All computer-assigning teachers	35	45	3	16	100	(1,261)

Universe: Probability sample, questionnaire versions 1 and 2; teachers who used computers with students in their selected class.
*The category "mixed" refers to situations where teachers selected more than one platform as primary in one location or selected two locations with different primary platforms as equally common places where their students used computers for their selected class.

PART II. EXTENT AND VARIETY OF SOFTWARE USED AND TEACHERS' OBJECTIVES FOR USE

TYPES OF SOFTWARE USED

Studies of instructional uses of school computers conducted in the 1980's and early in the 1990's found that the primary uses of computer technology in schools involved students practicing basic math and language arts skills and becoming "computer literate" (e.g., learning how to use different types of software). Today, although a large fraction of students' use of computers still occurs in special computer classes and pull-out programs, we are seeing larger numbers of teachers going beyond simple skills practice or basic computer literacy and having their students use computers to do productive work—for example, searching for information and producing written and visual products that reflect their cognitive and creative effort.

Of all of the various types of software available on school computers, word processing software is by far the most commonly used. Not only are English teachers, business education teachers and computer teachers more likely to have their students do word processing than any other computer activity, but so are science, social studies, vocational education, and elementary teachers. (See Table 7, where percentages of teachers who use "word proc." are shown in the first data column.) Altogether, 50% of all 4th through 12th grade teachers have students use word processing software at least occasionally during class time.

Among elementary classes, games for practicing basic math and language arts skills are still common (second only to word processing). However in secondary schools, games are used much less frequently. In middle schools, drills and games are used by fewer teachers' students than are CD-ROM reference software or Web browsers. In high schools, drill and game software is used by fewer teachers' students than graphics software, spreadsheets, simulation and exploratory software, computer-aided presentations software (e.g., PowerPoint), CD-ROMs or web browsers.

Mathematics teachers, however, appear to be an exception to this trend of using "tool-oriented" computer applications in secondary schools (except perhaps for their use of graphing calculators, which was not part of this survey of *computer* use). More math teachers use skills-practice games than any other type of computer software.[7] Table 7 shows the percentage of teachers, by subject, who reported having their students use each of ten different types of software on at least three occasions during the year.

[7] Note that "graphing software" was not a category used in the survey. However, graphing programs were mentioned by relatively few math teachers in an open-ended question about the specific software they found to be most valuable with their students.

TABLE 7: PERCENT OF TEACHERS REPORTING STUDENT USE* OF SOFTWARE DURING CLASS, BY TYPE OF SOFTWARE AND SUBJECT & LEVEL TAUGHT

Subject and Level Taught**	Word Proc.	CD-ROM	Word Wide Web	Skill practice games	Simulations/ Exploratory Environments	Graphics	Spread-sheets/ Database	Present-ation	Multi-media	E-mail
Elementary Self-contained	69	56	24	66	36	27	8	7	11	8
Elementary Other	58	48	29	53	23	27	13	10	19	6
English	60	39	34	12	10	16	9	12	5	7
Science	39	35	35	9	22	16	19	8	8	9
Math	14	7	16	23	17	7	13	5	3	1
Social Studies	37	32	30	10	12	11	12	16	11	8
Foreign Language	32	17	32	16	5	13	9	2	8	3
Mixed Academic Sec.	75	70	33	27	33	30	16	10	9	10
Computers	87	32	48	48	48	54	67	45	21	16
Business	86	22	37	23	48	40	63	48	5	13
Vocational	40	28	36	16	42	42	24	22	10	13
Fine Arts	23	9	21	3	13	29	8	12	7	8
Other Applied Secondary	37	22	21	12	20	15	13	14	7	2
Elementary	66	54	26	62	28	27	10	8	13	7
Middle School	43	31	26	21	18	18	16	11	8	6
High School	45	29	25	12	21	20	20	15	8	8
All teachers	50	34	29	28	23	21	16	12	9	7

Universe: All teachers in probability sample. For N's, see Table 1.
*"Use" defined as students in any of the teacher's classes having used that type of software on 3 or more occasions.
**"Subject" defined as the subject occupying a majority of the teacher's workload.

40%+
30-39%
20-29%

As Table 7 shows, besides word processing software for composing and editing text, two other types of software are in widespread use—CD-ROM reference software and World Wide Web browsing software. Both of these enable students to gather information for research or simply to explore. In elementary school teachers' practices, the more controlled information bases on CD-ROMs are used much more often than the more wide-open information repositories on the Internet. However, in high schools the World Wide Web is used at least as often as CD-ROMs, and the Web is the information resource of choice particularly in computer-assigning foreign language classes, fine arts classes, computer classes, and business education classes.

Use of *analytic software*—such as spreadsheets, simulations and exploratory environments—and *product-oriented software*—such as presentation software, graphics programs, and multimedia authoring environments—are used by fewer academic subject-matter teachers than use word processing or information retrieval software. However, computer and business education teachers are *more likely* to use most types of analytic and product-oriented software than they are to use information retrieval technologies like CD-ROMs and the World Wide Web. For example, two-thirds of computer teachers and business education teachers have students use spreadsheets while only about one-fourth to one-third have students use CD-ROMs. In contrast, only 19% of science teachers' students use spreadsheets, but nearly twice that number have students use CD-ROMs. More than one-third of computer and business education teachers have their students use presentation software, but that is done by only about 10% of teachers in the academic subjects.

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Overall, the *broadest use* of different types of software occurs among computer and business education teachers, and the next broadest use is among secondary vocational education teachers, elementary teachers, and a group we call "secondary teachers of mixed or other academic subjects." Those teachers are much more likely to have students use a variety of software—or any one type of software—than are more traditional "single subject" secondary teachers. That pattern is even clearer in Table 8, which shows the percentage of each group of teachers whose students used each type of software on at least 10 occasions during the school year (actually, over the 8 months, on average, between the start of the school year and the completion of the survey).

TABLE 8: PERCENT OF TEACHERS REPORTING FREQUENT STUDENT USE (USE IN AT LEAST 10 LESSONS), BY TYPE OF SOFTWARE AND SUBJECT & LEVEL TAUGHT

	Word Proc	CD-ROM	World Wide Web	Skill practice games	Simulations/ Exploratory Environments	Graphics	Spread-sheets/ Database	Present-ation	Multi-media	E-mail
Elementary Self-contained	49	30	11	37	12	11	2	2	4	3
Elementary Other	39	25	12	22	8	7	1	3	7	3
English	38	10	12	4	2	6	2	4	2	2
Science	24	15	22	3	5	6	8	5	2	4
Math	4	2	4	13	8	1	4	2	1	1
Social Studies	20	16	14	2	3	5	4	5	6	6
Foreign Language	4	4	4	11	0	0	9	0	0	0
Mixed Academic Secondary	58	34	21	10	7	17	9	6	8	5
Computers	76	15	38	20	22	23	43	29	13	9
Business	78	3	14	16	19	20	47	22	2	5
Vocational	15	12	15	1	21	16	7	6	3	3
Fine Arts	10	4	7	0	1	15	0	1	2	1
Other Applied Secondary	18	4	5	7	2	7	4	4	3	1
Elementary	46	28	12	32	11	10	2	3	5	3
Middle School	26	13	12	9	7	6	8	5	4	2
High School	30	10	16	5	6	9	9	7	3	4
All teachers	32	16	13	14	7	8	7	5	4	3

Universe: All teachers in probability sample. For N's, see Table 1.
"Frequent Use" defined as students in any of the teacher's classes having used that type of software on 10 or more occasions.
"Subject" defined as in Table 7.

40%+
30-39%
20-29%

Table 8 shows that there are relatively few examples where a given type of software is being used frequently by at least of one-third teachers of any one subject. Only 11 times (out of 130 possible cells in the first panel of Table 8) do we see frequent use by at least one-third of all teachers with their classes. Word processing accounted for nearly half of those (6), led, not surprisingly, by computer teachers and business education teachers, three-fourths of which had students use word processing on at least ten occasions. Computer and business education teachers accounted for 3 more examples, involving Web use and spreadsheets. The final two examples were elementary self-contained class teachers' use of skill practice games and mixed academic secondary teachers' use of CD-ROMs. The rest of the combinations of computer use by subject (119 of them) involved only a small percentage of teachers. For example, among English teachers only 4% had students use presentation software on at least 10 occasions. Among science teachers, only 5% had students use simulation or modeling software that often. Among

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vocational teachers, only 7% had students make frequent use of spreadsheets or database software. And only 4% of math teachers had students use word processing 10 times. Outside of business and computer teachers, outside of word processing, CD-ROM use, and World Wide Web use, and outside of skill practice games in elementary school, there were almost no examples of a type of software being used frequently by more than 20% of any one category of teacher.

In summary, it appears that most types of software have their widest diffusion in applied and elective areas of the secondary school curriculum where teachers are freer to adopt technology-based approaches to instruction. Except for word processing, CD-ROM software, and the World Wide Web, relatively few college preparatory academic teachers (who are perhaps constrained by their notion of college admission standards) even experiment with simulation software, graphics software, presentation software, spreadsheets, or databases.

Teachers in those subjects not only have fewer classroom computers, but they may be more constrained by expectations for subject-matter coverage against implementing teaching approaches in which computer activities are tools for student projects. As a result, one would not expect to find major outcomes of student computer use in schools by examining high school students' achievement on academic tests of mathematics skill or science or social studies knowledge. It would be more appropriate to attend to the competencies likely to be affected by the ways computers are used—primarily, given the broad use of word processing, in terms of writing competence, and in a range of applied secondary courses where teachers prepare students to be productive users of occupationally relevant technology tools and resources.

SOFTWARE THAT TEACHERS JUDGE AS MOST VALUABLE FOR STUDENTS

Separately from asking teachers about how often they had students use different types of software, we also asked teachers to name several of the "best" or "most valuable" software programs that students in their selected class had used (including Internet access software).[8] Programs named as "best" or "most valuable" by 5% or more of all computer-assigning teachers of a given subject are shown in Table 9.

ClarisWorks (now AppleWorks), the integrated office application, is clearly the program most widely viewed by teachers as most valuable for students. Twenty percent of both elementary and middle school teachers who gave students computer work found it to be one of the two or three best programs for students, as did 12% of high school teachers who assigned computer work. In every subject category except business education, at least 10% of computer-assigning teachers judged it that way. At the secondary level, in those subjects where teachers are least likely to frequently assign computer work (i.e., academic subject teachers and teachers of fine arts) it is named by at least 15% of computer-assigning teachers. Interestingly, in secondary subjects where teachers are *most* likely to assign computer work to students on a frequent basis (i.e., computer and business classes), teachers are less likely to name ClarisWorks as one of their most valuable programs. ClarisWorks, thus, appears to serve as an easy-entry general-purpose software tool that meets the needs of occasional computer-assigning teachers. When they become more expert and more specialized in their needs, they move on to other programs for fulfilling these basic office functions.

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[8] The question about "best programs used by students" was asked of 50% of the survey sample. The question about the "most valuable" software was asked of the other 50%. The latter question, though, was asked differently—it incorporated both teacher use and student use and inquired separately about each of the past five years. The analysis in this section incorporates answers from both questions, except that for the second group, only reports about the past two years are included and only when the software appeared to be used by students rather than the teacher herself.

TABLE 9: SPECIFIC SOFTWARE REPORTED AS "BEST" OR "MOST VALUABLE" FOR STUDENTS BY COMPUTER-ASSIGNING TEACHERS, BY SUBJECT & LEVEL OF TEACHER

	Percent of All Computer-Assigning Teachers (naming at least one program as "best")*			
	20%+	15-19%	10-14%	5-9%
Elementary Self-contained	ClarisWorks		**Hyperstudio**	**Accelerated Reader****, Encarta, Groliers, M. Word, Netscape, **Oregon Trail**, Writing-Pub. Center
Elementary Other	ClarisWorks	**Accelerated Reader**	**Hyperstudio**	Groliers, M. Works, Netscape, Writing-Pub. Center
English		ClarisWorks, M.Works	M. Word, Netscape	**Accelerated Reader**, Powerpoint
Science		ClarisWorks, Netscape		**Hyperstudio**, M.Office, M.Word, M.Works
Math	**Geometer's Sketchpad**	ClarisWorks		Excel, **Math Blaster**, M.Word, Netscape
Social Studies		ClarisWorks, Netscape	**Hyperstudio**	Encarta, Groliers, I.E., M.Word, M.Works, Powerpoint
Foreign Language	ClarisWorks, M.Word	**M.Publisher**	Netscape	M.Works, Powerpoint
Misc. Academic Secondary	ClarisWorks		Encarta, M.Word, Netscape	Groliers, M.Office
Computers		M.Office, Netscape	ClarisWorks, M.Word, M.Works, Word Perfect	Excel, **Hyperstudio**, Powerpoint
Business	M.Works, Word Perfect	M.Office	M.Word	ClarisWorks, Excel, Netscape
Vocational	**AutoCAD**	Netscape	ClarisWorks, Word Perfect	M.Office, M. Works
Fine Arts	ClarisWorks	**PhotoShop**	Netscape	**Hyperstudio**, M.Word, M.Works, **PageMaker**
Other Applied Secondary	ClarisWorks	M.Word, M.Works, Netscape, Powerpoint		**Hyperstudio**, M.Office, Word Perfect
Elementary	ClarisWorks		**Hyperstudio**	**Accelerated Reader**, M.Word, Netscape, Encarta, Groliers, M.Works, **Oregon Trail**
Middle School	ClarisWorks		Netscape	M.Works, M.Word, **Hyperstudio**
High School			Netscape, M.Works ClarisWorks, MWord	M. Office, Powerpoint, Word Perfect
All comp.-assigning teachers		ClarisWorks	Netscape	M.Word, M.Works, **Hyperstudio**, M.Office

Probability and purposive samples; teachers who assigned computer work to selected class and who named at least one program.
*One-half of teachers responded to a question about the "best computer programs students in this class have used." The other one-half responded to a question about their most valuable software in each of the past five years. Data from the two most recent years were taken from this latter group, and only if the software did not seem to be named primarily because of its value for the teacher's own professional use.
** Software in bold are applications other than office software, Internet access software, or CD-ROM encyclopedias. They are primarily subject-specific applications or authoring tools.

Among middle and high school teachers, three other programs besides ClarisWorks were named by at least 10% of computer-assigning teachers as among their "best" for student work. One was another integrated office application (Microsoft Works), one was a word processor (Microsoft Word), and the third was the dominant Web browser during 1998, Netscape.

However, two very different kinds of programs found adherents among a substantial percentage of elementary computer-assigning teachers. The multimedia authoring program, Hyperstudio, was named as "best" by 11% of computer-assigning elementary teachers (and by 10% of secondary social studies teachers as well). The tradebook-oriented computer-based testing program, Accelerated Reader, was named by 9% of computer-assigning elementary teachers and by 6% of secondary English teachers as

well. Neither of these programs fit into the office application-web-browser-generic tool category of the other popular programs. Hyperstudio is used for enabling students to produce media-integrated products, while Accelerated Reader has become a highly popular system for increasing student effort in reading. (In Table 9, all "specialized" software—that is, other than the most common office applications or Web browser software—is shown in bold type.)

In a few secondary school subjects, one or two specialized software titles have become popular with a substantial fraction of computer-assigning teachers. In mathematics, the inductively-oriented program, Geometer's Sketchpad, was mentioned by more than one-fifth (21%) of all math teachers who reported a "most valuable" software title for use with their students. Similarly, the adult-level automated drafting program, AutoCAD, was reported to be their most valuable software by nearly one-fourth (24%) of all vocational education teachers who used computers with their classes.

In vocational education classes, AutoCAD plays a similar role that adult-level office software (e.g., Microsoft Office, Word Perfect, etc.) does in business education classes—as an occupational tool for which skill mastery is an explicit goal. However, the high percentage of mathematics teachers who reported Geometer's Sketchpad to be among their best software was unexpected. Most academic subject areas have many specialized software titles, causing utilization to be split among many different programs. Moreover, most computer-assigning mathematics teachers use very traditional skill-practice software, and Geometer's Sketchpad is oriented very differently, towards inductive reasoning and exploration of hypotheses. (In comparison, the spreadsheet program Excel was selected by only 8% of computer-assigning math teachers.) Finally, the Sketchpad program has its principal applicability in only one area of mathematics rather than being used across the full mathematics curriculum.

Besides Sketchpad and AutoCAD, the only non-office, non-web-browser programs to be selected by more than 10% of computer-assigning teachers in any given subject were PhotoShop, the adult-level image-editing program, chosen by 18% of computer-assigning fine arts teachers, and Microsoft Publisher, a graphics-oriented word processing program, named by 14% of the small number of computer-assigning foreign language teachers.

The only other software (besides other word processing and office oriented titles) to appear in Table 9's list of software selected by at least 5% of computer-assigning teachers of particular subjects were two CD-ROM-based encyclopedias (Encarta and Groliers), the game-like social studies simulation Oregon Trail, and "math blaster" type math drills. Recall, though, that Table 9 does not show all of the software that teachers use with students, but only those titles named by teachers as "best" or "most valuable" for use with students.

PATTERNS OF SOFTWARE USE

Some teachers have their students use only one or two types of software, while other teachers integrate a variety of types of software into their students' learning. For example, many teachers have their students *only* use word processing or *only* skill-practice games and drills and don't have them use other computer applications except occasionally. At the other extreme, teachers whose students frequently use multimedia authoring or presentation software or e-mail typically have their students use many other types of software as well. Specifically, one-half (51%) of teachers whose students frequently use multimedia authoring software also at least occasionally have students play computer games for practicing skills, but only 17% of teachers whose students frequently use computer-based skill games also use multimedia software on occasion. The same pattern exists for teachers who used e-mail and presentation software—that is, a much higher proportion of them also reported using games but the reverse was not true.

We can see three reasons for the difference in the breadth of computer-based teaching between teachers whose students use word-processing or skill-games and those who have students use presentation, e-mail, and multimedia software. First, these two groups of teachers may have different teaching responsibilities. Teachers of computer classes would be likely to have students use a greater variety of software than would history teachers, for example. Second, there is an order of difficulty involved in the use of different types of software. In order for their students to use presentation software or multimedia authoring software, teachers must have greater facility with having students do computer-based projects, and they may need more general expertise in the use of computers as well. Third, teachers whose students do e-mail and multimedia projects may have different objectives for computer use and different teaching philosophies than those who assign computer-based drills or word processing. For example, they may see students using computers to learn through making products or through communicating ideas to others while skill-game-using teachers and even many word-processing-assigning teachers may see computers as valuable for students to simply "do school work." In this section of this report, we examine the patterns of software use among different groups of teachers, and how their pattern of use relates to their teaching responsibilities, computer expertise, and their objectives for computer use.

A Typology of Teachers' Software Use

"Cluster Analysis" is an iterative process of sorting people's responses to survey questions into a set of categories so that people with similar patterns of responses are grouped into the same category. In this case, the survey responses are each teacher's report of the frequency that they had their students use each of 10 types of software. Because the age of their students so clearly affects the types of software that teachers use, the sorting was done separately for elementary, middle, and high school teachers. Only teachers who reported some use of software by their students during class were included in the analysis. For each level of teaching, we specified that the clustering procedure[9] produce 10 different groups defined according to the similarity and distinctions in their reports of how frequently they had students use different types of software.

For all three levels, the largest number of computer-assigning teachers were part of a cluster we would call "limited users." These are teachers who do have students use computers, but no type of software is used more than occasionally (among the 10 software types listed in the questionnaire). These limited users constitute nearly 30% of all teachers. (See Table 10.) When added to the 30% of teachers who do

[9] K-Means clustering (or "Quick Cluster" in SPSS).

TABLE 10: CLUSTER ANALYSIS OF PATTERN OF SOFTWARE USE (MEAN SCALE SCORES*)

ELEMENTARY CLUSTER PROFILES

Cluster:	1-1	1-2	1-3	1-4	1-5	1-6	1-7	1-8	1-9	1-10
Unweighted (N)	(306)	(163)	(97)	(65)	(52)	(108)	(10)	(82)	(36)	(35)
Weighted (N)	(241)	(124)	(85)	(50)	(26)	(55)	(7)	(60)	(25)	(14)
% within Elementary level**	30%	15%	10%	6%	3%	7%	1%	7%	3%	2%
Word Processing	1.5	8.0	5.5	6.5	6.0	6.0	2.4	7.7	7.9	8.0
CD-ROM Reference	1.4	1.6	8.0	1.6	3.8	5.9	6.8	6.8	7.5	7.8
WWW Browser	0.6	1.1	0.8	0.7	2.1	8.0	1.2	3.9	0.4	7.5
Games	2.9	3.5	3.8	6.0	3.0	4.7	2.9	7.6	7.1	5.5
Graphics Oriented Printing	0.5	0.7	1.5	5.9	2.2	2.0	5.1	1.9	7.8	5.9
Simulations	1.0	1.0	1.0	2.2	1.8	1.5	5.7	7.5	4.3	5.4
Spreadsheet/Database	0.2	0.9	0.4	0.3	1.4	0.6	1.4	0.6	2.4	3.6
Presentation software	0.2	0.4	0.6	0.9	3.0	1.3	0.0	0.5	1.1	7.4
Multimedia	0.2	0.5	0.5	0.5	7.9	1.2	8.0	0.5	1.4	7.2
E-Mail	0.2	0.3	0.4	0.2	0.5	2.4	2.0	1.0	0.4	4.5
Total	8.7	18.0	22.5	24.8	31.7	33.6	35.5	38.0	40.3	62.8
% students used twice/week	17%	20%	22%	28%	46%	49%	14%	39%	24%	64%

MIDDLE SCHOOL CLUSTER PROFILES

Cluster:	2-1	2-2	2-3	2-4	2-5	2-6	2-7	2-8	2-9	2-10
Unweighted (N)	(463)	(173)	(59)	(50)	(71)	(98)	(43)	(51)	(42)	(53)
Weighted (N)	(459)	(165)	(74)	(44)	(52)	(80)	(30)	(36)	(28)	(34)
% within Middle School level**	31%	11%	5%	3%	4%	5%	2%	2%	2%	2%
Word Processing	1.6	8.0	2.5	2.2	3.9	7.2	7.7	8.0	6.5	8.0
CD-ROM Reference	1.0	2.3	1.0	5.5	1.7	8.0	6.5	3.7	4.1	6.2
WWW Browser	1.0	0.8	1.2	1.3	7.9	6.8	1.5	7.7	4.1	7.8
Games	0.8	1.0	7.9	1.1	0.8	1.6	6.5	1.1	3.7	4.7
Graphics Oriented Printing	0.6	1.9	0.5	1.3	1.7	2.0	4.5	3.5	7.7	3.9
Simulations	0.8	1.0	3.1	1.6	1.4	1.2	5.8	1.4	3.5	3.7
Spreadsheet/Database	0.6	1.6	2.5	1.0	0.8	1.2	1.2	3.4	5.3	4.8
Presentation software	0.4	0.8	0.6	2.5	1.5	1.7	1.5	4.0	7.3	6.1
Multimedia	0.2	0.5	0.3	3.2	0.5	0.6	0.9	4.6	5.9	3.9
E-Mail	0.2	0.4	0.1	0.4	1.9	1.0	0.3	1.3	0.2	7.5
Total	7.2	18.3	19.7	20.1	22.1	31.3	36.4	38.7	48.3	56.6
% students used twice/week	7%	22%	20%	25%	31%	30%	27%	41%	59%	43%

HIGH SCHOOL CLUSTER PROFILES

Cluster:	3-1	3-2	3-3	3-4	3-5	3-6	3-7	3-8	3-9	3-10
Unweighted (N)	(347)	(70)	(55)	(69)	(220)	(107)	(57)	(59)	(45)	(37)
Weighted (N)	(420)	(84)	(57)	(68)	(239)	(104)	(46)	(40)	(36)	(27)
% within High School Level**	24%	5%	3%	4%	14%	6%	3%	2%	2%	2%
Word Processing	1.3	0.7	3.9	2.0	8.0	6.1	5.7	7.9	7.9	7.9
CD-ROM Reference	0.9	1.2	1.0	3.6	3.0	0.9	2.5	7.1	2.1	3.1
WWW Browser	1.1	1.0	1.3	7.0	3.4	2.1	6.7	7.7	6.1	4.6
Games	0.4	3.7	0.2	0.7	1.1	0.9	0.5	1.0	4.7	0.6
Graphics Oriented Printing	0.4	0.3	8.0	0.8	0.9	2.4	2.6	5.3	2.8	7.9
Simulations	0.6	4.2	1.3	1.5	1.3	2.9	1.3	0.9	3.0	6.8
Spreadsheet/Database	0.6	0.6	1.2	1.4	0.7	7.2	1.2	2.7	7.7	7.0
Presentation software	0.4	0.6	0.8	1.2	0.9	1.3	1.7	6.6	6.6	8.0
Multimedia	0.2	0.4	1.4	0.7	0.5	0.4	1.1	2.0	3.3	2.7
E-Mail	0.2	0.1	0.3	0.8	0.6	0.6	7.8	2.7	1.8	2.5
Total	6.1	12.8	19.4	19.7	20.4	24.8	31.1	43.9	46.0	51.1
% students used twice/week	7%	13%	53%	15%	20%	57%	29%	45%	68%	71%

Universe: Probability and purposive samples; teachers who assign computer work in any class they teach.

* Scale score entries have maximum values of 8.0. Scores based on the coding of the number of lessons in which teachers used software with students.

** Row does not add to 100%. The remaining teachers are those who do not use computers with students.

5.0 +
3.0 - 4.9
1.8 - 2.9

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not use computers with students at all (Table 1), this leaves only 40% of teachers whose pattern of computer use we will discuss in this section.[10]

Each of the clusters 2 through 10 (numbered 1-2 to 1-10 for elementary, 2-2 to 2-10 for middle, and 3-2 through 3-10 for high school) are teachers whose pattern of student software use is relatively homogeneous and distinct. We will describe several of these at each school level; the remainder can be characterized by an examination of Table 10.

Selected Elementary Level Clusters

At the elementary level, 15% of teachers belong to Cluster 1-2. These teachers have students use word processing frequently (the score of 8.0 in Table 10 for Cluster 1-2's use of word processing is the maximum possible in our coding system), but they rarely have students use any other type of software, except for skill-related computer games. In contrast, in elementary Cluster 1-8, which encompasses 7% of all elementary teachers (grades 4-6), students make relatively frequent use of three types of software besides word processing: CD-ROM reference titles, skill-related games, and simulation software. In addition, students in Cluster 1-8 classes occasionally use the World Wide Web. For further contrast, in elementary Cluster 1-5, involving 3% of all upper-grade elementary teachers, the software that students use the most–even more than word processing–involves assembling and producing their own multimedia presentations. In Cluster 1-5, students don't use computers more than in Cluster 1-8; they just use it differently. They are less likely to use skill-based computer games or CD-ROMs, and make hardly any use of simulations, but they do occasionally use software to present their work to their classmates. Thus, in Cluster 1-5 students' use is oriented more towards producing and explaining things rather than acquiring facts or using games or exercises to learn basic skills. In the final section of this report, we will show a number of ways that teachers in these three clusters (and others) differ from one another. For example, teachers in Cluster 1-5 are more than twice as likely as teachers in the other two clusters, 1-2 and 1-8, to be highly proficient in computer skills themselves (i.e., scoring in the upper-third of teachers on a measure of expertise in computer operations).

Middle Grades Diverse-Use Clusters

At the middle school level, there are five different clusters whose teachers provide students with a substantial variety and frequency of computer use (Clusters 2-6 through 2-10). However, each of the five diverse-use clusters has a relatively distinct pattern in the types of software students use. Students in all five clusters make substantial use of word processing, but Cluster 2-6 is otherwise focused only on CD-ROMs and the World Wide Web, while Cluster 2-7 teachers have students use CD-ROMs, games, and simulations, but not the Web, and Cluster 2-8 teachers' students use the Web a great deal, along with more occasional use of a variety of software including spreadsheets, presentation software, and multimedia authoring. Cluster 2-9 teachers' students are particularly heavy users of presentation software, multimedia authoring, and graphics related programs for printed output, but they are not as "information"-oriented as Clusters 2-6 through 2-8. Cluster 2-10 shows the broadest pattern of software use even extending to student electronic mail. Altogether, these five clusters involve only 14% of all

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[10] In order to make use of all teachers' data, the percentages and rates in this section come from the full set of TLC schools—that is, both the probability sample and the various purposively selected reform-involved and high-technology schools. However, in many respects, differences among these two samples of teachers are hardly noticeable. For example, the percentage of teachers who are in clusters 2 through 10 combined (whom we might call "regular computer-assigning teachers") is nearly the same in the probability sample as it is among the teachers in the reform-plus-high-tech TLC schools (the purposive sample). For example, 54% of probability-sample elementary teachers regularly assign computer work compared to 56% of teachers in the elementary schools in the purposive sample. (Comparable percentages for middle school teachers are 37% for each sample; and for high school teachers, 42% in the probability sample and 39% in the purposive sample.)

middle school teachers. About an equal number of computer-assigning middle school teachers fall into just two other clusters: the 11% whose main student computer activity is word-processing plus the 5% whose primary activity is skill-related computer games.

At the secondary school levels, both middle- and high school, subject-matter responsibilities strongly affect the placement of teachers into different clusters. Three groups of middle-grades teachers are particularly likely to be in the five "diverse-use clusters"—teachers who primarily teach classes in computers, vocational education teachers, and teachers of mixed academic subjects. Those teachers are about twice as likely to be in one of the diverse-use clusters than into one of the others, "limited-use" or "specialized-use" clusters. For comparison, most of the single-subject academic teachers are split about evenly between limited- or specialized-use clusters and diverse-use clusters. The most sharply distinctive pattern is held by computer-assigning middle grades mathematics teachers. Those teachers are *five times as likely* to be in the limited- or specialized-use clusters as in the diverse-use clusters. Looked at another way, only 4% of the diverse-use cluster teachers are from math, whereas math teachers comprise 20% of the limited- or specialized-use cluster teachers. (See supplementary Table A-1 in Appendix A.)

High School High-Use Clusters

In high schools, the most active computer-assigning teachers also fall into five clusters. As with the more diverse-use clusters at the middle school level, relatively few teachers belong to these upper-end clusters. Altogether, for example, only 6% of high school teachers comprise Clusters 3-8 through 3-10, and only 9% additionally comprise Clusters 3-6 and 3-7. Although three-fourths (78%) of all teachers of computer education courses belong to these five clusters, only 12% of science teachers, 9% of English and social studies teachers, and 5% of math teachers do. (See supplementary Table A-2.)

One of these high-use clusters (Cluster 3-6) is focused on the traditional computer literacy applications of instruction in word processing, spreadsheet, and database software–and almost *nothing else*. More than half (53%) of the teachers in this cluster are computer education or business education teachers. (See supplementary Table A-3.) Another cluster (3-7) is heavily Internet-dominated, involving not only substantial use of the Web, but substantial student use of electronic mail as well. The teachers in this cluster come primarily from academic subjects, most commonly English (25% of Cluster 3-7 teachers). In this group, comparatively few teachers report that typical students in the classroom have used computers more than 40 days (twice/weekly) during the year. (See the bottom row in Table 10.) This may have to do with having a limited number of convenient Internet connections and e-mail accounts, since at the time of this study few academic classrooms had high-speed Internet connections and few schools provided (or yet provide) e-mail accounts to students on locally-controlled servers.

The other three high-use high school clusters are characterized by substantial use of *both* word processing *and* presentation software—in other words, both writing and speaking. Cluster 3-8 involves courses that are information-oriented; both CD-ROM reference software and World Wide Web browsers accompany the word processing and Powerpoint (presentation) activities. Like the previous cluster, 3-7, it is also primarily drawn from teachers of academic subjects, and, again, English teachers are most prevalent.

In contrast, Clusters 3-9 and 3-10 are primarily populated by teachers of computer classes and business education classes. Both involve the frequent use of several types of software in addition to word processing and presentation software, with most other types of software used occasionally as well. For Cluster 3-9, the most-used software includes spreadsheets and Web browsers. For Cluster 3-10, it includes spreadsheets, simulations, and graphics-oriented print programs. At this point, it is hard to see what distinguishes these final two clusters. However, as we will show later, one cluster is heavily drawn from teachers whose computer access is in their own classroom, while the other cluster overwhelmingly

uses computer labs. One cluster's teachers teach students who are high in overall academic achievement and teach in high socio-economic status communities; the other's students are slightly below average in academic achievement and come from lower than average socio-economic backgrounds. We will explore those differences further at the end of this paper.

Middle and High School "Specialized-Use" Clusters

At each school level, some clusters are characterized by the use of one particular type of software with students, if not exclusively then at least far more than any other type. We already pointed to Cluster 1-2 at the elementary level, whose students experience computers primarily through word processing (and secondarily through games). Cluster 2-2 is similar at the middle school level, except that CD-ROMs and graphics-oriented printing substitute for games as a secondary computer activity. Cluster 3-5 is comparable for high school teachers except that these teachers also have their students use the World Wide Web and/or CD-ROMs. English teachers and science teachers constitute the largest fraction of teachers who fit the "primarily word-processing" Clusters 2-2 and 3-5.

Math teachers constitute nearly one-half (47%) of the teachers in middle school Cluster 2-3, in which skill-based games are the dominant mode of computer activity, supported by simulations and limited spreadsheet or database work. Industrial arts and fine arts teachers together are the majority of teachers in high school Cluster 3-3, whose teachers report very frequent use of graphics software (CAD in industrial arts, varied drawing and design software in fine arts) along with word processing software as well. High school science teachers are one-third (33%) of the teachers in Cluster 3-4, where use focuses on World Wide Web browser programs like Netscape, along with some CD-ROM reference software. Interestingly enough, very little word processing is done in those classes. A somewhat similar cluster, 2-5, is formed at the middle school level by teachers from a wide range of subjects whose students use Web browser software supported by word processing.

Although the teachers in these "specialized-use" clusters have students use a less varied array of software, many of them make computers a part of their classes' instructional activities. Overall, about 25% of the teachers in these clusters have had their "typical student" use computers on more than 40 occasions during the year (twice/weekly). Thus, another way of classifying teachers would be to create categories based on both extent of student computer use and variety of software used. Supplementary Table A-4 describes how teachers of specific subjects are allocated among several categories of diversity and frequency of student software use. (That table employs a somewhat weaker "weekly or more" frequency of use criterion.)

After we discuss several other aspects of teachers' computer use—the objectives they have for students' use, their students' use of computers outside of class, the extent to which they use computers themselves professionally, and their self-perceived expertise in using computers—we will provide a richer portrait of many of these software-use clusters.

OBJECTIVES FOR COMPUTER USE

Not only is there a wide variety of different kinds of software that teachers can use with students, but most types of software can be used for different instructional purposes by different teachers. For example, one teacher may have students do word processing in order to improve how well they communicate their ideas, while another teacher may have students use the same software so they can become more proficient in basic grammar, and another may have students do word processing in pairs or triplets in order for them to learn to work more collaboratively. We asked each teacher whose selected

class used computers to indicate which of ten different objectives they had for their students' computer use, and then to pick the three objectives that were most important for them.

Across grades 4 to 12, the two most commonly selected objectives of teachers who assign computer work to their students were "finding out about ideas and information" (51%) and "expressing themselves in writing" (44%)—two objectives closely linked to the two most common types of software in use word processing and CD-ROM reference software. (See Table 11.) Third and fourth in teachers' estimation were "mastering skills" (37%) and "improving computer skills" (32%). Although previous national surveys did not ask the same questions about teachers' objectives, other data from those earlier surveys conducted in 1989 and 1992 suggests that the rank-ordering between these pairs of objectives (basic skills and computer skills versus writing and information-seeking) has flip-flopped over the past decade. In other words, the use of computers to have students learn content knowledge and to improve their writing has taken over from the "computer literacy" and "skills practice" objectives that dominated students' teacher-directed computer use during the 1970s and 1980s. This suggests that teachers are now seeing computers as advantageous for somewhat more complex competencies than the role they assigned to computers heretofore.[11]

Even among elementary teachers, the writing and information-acquisition objectives were more common than the skills objectives. In fact, a higher percentage of elementary (grade 4-6) computer-assigning teachers than secondary teachers named "writing" as a principal objective. Still, elementary teachers were also more likely than teachers at other levels were to report that "remediation of skills not learned well" and "computer skills" were among their top three objectives for computer use. In contrast, computer-assigning teachers of older children were more likely to point to objectives such as having students analyze information and present it to others as a main reason for using computers.

Quite understandably, teachers of different subjects also have different objectives for their students' computer use. (See Table 11 for overall differences and see supplementary Table A-5 for numerical percentages.) Some of the differences are self-evident—for example, that English teachers are more likely than other teachers to use computers to help students improve their writing, or that computer teachers are more apt than others to have "improving computer skills" as a principal objective. However, other patterns of objectives chosen in response to this survey question suggest that different pedagogical perspectives may characterize teachers of different subjects. For example, the teachers most likely to believe that a main objective for using computers is "remediation of skills not previously learned" are business education teachers (82% of which selected this objective). (Also, math teachers were more likely than others were to make this choice, clearly by using computer-based drills and games for that purpose.) Foreign language and vocational education teachers were more likely than other teachers were to value computers for helping students to work at learning their subject independently from others.

[11] An important reservation to this claim should be noted: A large fraction of students' more intensive computer experiences occur in computer education and business education classes, and teachers of those classes are less likely than average to prioritize improvement of student writing as a primary objective. (See text below)

TABLE 11. SUBJECT-MATTER TEACHERS MORE LIKELY AND LESS LIKELY THAN AVERAGE TO NAME EACH OBJECTIVE AMONG THEIR MOST IMPORTANT OBJECTIVES FOR STUDENT COMPUTER USE

	Much More Likely	More Likely		Less Likely	Much Less Likely
Finding out about ideas & info. (51% of all computer-assigning teachers)	Misc. Academic Social Studies			Foreign Lang.	Business Ed. Computer Ed. Math
Expressing self in writing (44%)	English	Elem. Self-Cont.		Business Ed.	Computer Ed. Math
Reinforcement ("Mastering skills just taught") (37%)	Business Ed. Math			English Social Studies Misc. Academic	
Computer skills (32%)	Computer Ed.	Business Ed. Elem. Self-Cont.	Average	English Foreign Lang. Fine Arts	
Analyzing information (27%)	Science Computer Ed.	Foreign Lang.			
Remediation of skills (24%)	Math	Elem. Other		Social Studies Misc. Academic Computer Ed. Vocational Ed.	
Collaboration (24%)		Misc. Academic Social Studies		Elem. Other	Foreign Lang.
Independent work (23%)	Foreign Lang. Vocational Ed.	Business Ed. Fine Arts		Science	
Presenting info. to an audience (18%)		Fine Arts English		Elementary	
Communicating electronically (9%)		Misc. Academic Computer Ed.			Math

What is also interesting is to identify the subjects whose teachers are *least* likely to select a given objective as among their most important ones for having students use computers. Foreign language teachers, for example, were much less likely than others to select "learning to work collaboratively," while math teachers were the least likely to see computers as useful for having students communicate electronically with other people. A future report in this series discusses subject-matter in terms of the teaching philosophies that these various objectives reflect.

Student Software Use by Teacher's Objectives for Computer Use

As the previous section showed, teachers have widely varying objectives for students' use of computers according to the subject-matter that they teach. For example, 82% of business education teachers report that reinforcing skill acquisition (mastering skills) is one of their top three objectives, compared to only 20% of social studies teachers. Do teachers with such different objectives also have students use different types of software or do they merely use the same types of software in different ways? In order to answer this question, we compared software use patterns for two groups of teachers—those who selected a given objective as being central to their use of computers versus those who did not select that objective. We repeated this for each of the 10 objectives. The greater the difference in use of a given type of software between those who selected an objective and those who did not, the more we regarded use of that software as conditional on having or not having that objective in mind.[12]

[12] We recognize that teachers might have different objectives for different types of software that they use. Unfortunately our data about teachers' objectives was not specific to one or another type of software but just to how

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One key finding is that academic skills-related objectives such as reinforcement or remediation are associated with greater use of the software category "games for practicing skills" and less use of everything else. This is consistent with the earlier finding that many teachers who use skill games software such as teachers in Cluster 2-3, are less likely to use other types of software. For example, of teachers with "mastering skills" as an objective, only 37% use CD-ROM resources compared to 59% of other teachers. Similarly, only 28% of the skills-mastery teachers have students use the World Wide Web compared to 50% of all other computer-assigning teachers. Comparable differences were found between teachers who prioritize "remediation" as an objective and those who do not.

Table 12 shows the situations where there are substantial differences in their students' use of particular types of software between teachers holding a given objective and those not reporting it as one of their top three.[13] Negative values indicate that a given type of software is *less* likely to be used by teachers rating an objective as central than by teachers who did not rate it so highly. For example, Table 12 shows that the standardized difference (effect size) for CD-ROM use between those who prioritize mastering skills as an objective and those who do not is a negative –.45.

TABLE 12. RELATIONSHIP BETWEEN OBJECTIVES FOR COMPUTER USE AND TYPES OF SOFTWARE USED (EFFECT SIZES)

Teachers Who Placed This Objective Among Their Three Most Important	Difference in Likelihood that Software Was Used by Teacher's Students (standardized difference in "% used" between teachers with/without that objective)									
	Word Proc.	CD-ROM	WWW	Games	Simula-tions	Graph-ics	Spread/ Data	Presen-tation	Multi-media	E-Mail
Finding out about ideas and info	.25	.70	.59							.29
Expressing in writing	.52	.39					**–.26**			
Mastering skills	**–.41**	**–.45**	**–.45**	.24		**–.23**		**–.25**	**–.32**	**–.26**
Improving computer skills		**–.23**		.20			.20			
Analyzing info				**–.22**	.22		.44			
Remediation of skills	**–.47**	**–.22**	**–.44**	.36		**–.37**	**–.37**	**–.28**		**–.35**
Learning to work collaboratively					.21			.23		
Learning to work independently		**–.36**							**–.22**	
Presenting info to an audience	.29			**–.27**	**–.30**	.44		.65	.56	
Communicating electronically	.45	.34	.46	**–.33**						.72

Universe: Probability sample; teachers who used computers with students in their selected class.

Highlighted statistics draw attention to negative differences indicating the types of software *less* likely to be used by teachers with certain objectives.

a particular teacher used computers with her students. The consequence of this data limitation is that if we find differences in objectives by software type, it is likely that the true differences are even larger than shown, since the teacher's objectives at best are "averaged" across different software that she uses.

[13] "Use" was defined as students using that type of software in at least three lessons during the year. Rather than employing the absolute difference in percent using between objective-holders and non-holders, that difference was divided by the combined sample standard deviation of "use/non-use," in effect creating an "effect size" measurement. This was to take into account the fact that differences between two very small (or very large) percentages need not be as large as differences between two modestly sized percentages for an equivalent "effect" to be registered. Effect sizes greater than .20 are show in the table.

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Information retrieval objectives (i.e., "finding out about ideas and information") are quite naturally associated with the use of CD-ROMs (68% vs. 33%, effect size = .70) and the World Wide Web (56% vs. 27%, E.S. = .59). But it is also the case that teachers who prioritize student written expression using computers also make use of CD-ROMs more than other teachers do (62% vs. 42%, E.S. = .39).

One other point: Teachers who prioritize having students use computers to present information to an audience not only are more likely than others to use presentation software, but they are also the primary leaders in student use of multimedia authoring software such as Hyperstudio. Thirty percent of such teachers use multimedia authoring software with their students compared to 10% of all other computer-assigning teachers. Looking at this from the opposite perspective, 39% of multimedia-authoring software users selected "presenting information to an audience" as a primary objective of student computer use compared to 15% of all other computer-assigning teachers.

Of course, this raises the question, if some users of multimedia authoring software do not see its primary value in terms of improving students' ability to present information to an audience, what are their objectives for that software's use? Table 13 highlights all those "high priority objectives" which were selected by at least one-third of the teachers who use each type of software frequently (that is, in 10 or more lessons during the year). (The entries indicate the percentage of those frequent-using teachers, including both the probability and purposive samples, who reported that particular objective.)

TABLE 13: PRIMARY OBJECTIVES SELECTED BY TEACHERS WHO FREQUENTLY USED SPECIFIC TYPES OF SOFTWARE WITH STUDENTS (PERCENT SELECTING OBJECTIVE)

		PERCENT SELECTING THESE OBJECTIVES AS ONE IN THE TOP 3									
Teachers whose students used this type of software in at least 10 lessons	(N)	% find out about ideas	% expression in writing	% mastering skills	% computer skills	% analyze info	% remediation	% work collaboratively	% work independently	% present info. to audience	% communicate electronically
Word Processing	(1,332)	**53**	**57**	28	32	24	15	23	24	26	11
CD-ROM Reference	(633)	**71**	**51**	23	26	29	18	26	18	22	10
WWW Browser	(657)	**71**	**46**	17	27	30	10	25	21	27	14
Skill Games	(477)	**49**	**44**	**45**	**37**	19	**39**	24	20	12	5
Graphics oriented	(359)	**42**	**35**	**34**	**41**	24	13	**33**	23	32	10
Simulation/ Exploratory	(329)	**50**	**34**	**43**	31	**34**	19	24	26	10	9
Spread/Database	(287)	**37**	27	**44**	**42**	**41**	10	25	31	19	11
Presentation s.w.	(297)	**43**	**36**	27	**34**	25	10	32	25	**46**	11
Multimedia Auth.	(235)	**49**	**45**	18	24	29	14	**36**	16	**45**	10
E-Mail	(201)	**58**	**43**	16	25	**34**	8	30	20	26	**33**

Universe: Probability and purposive samples; teachers who used a given type of software in 10 or more lessons during the school year. Highlighted statistics draw attention to those objectives selected by at least one third of teachers as one of their 3 most important objectives for student computer use.

Regardless of which types of software teachers use frequently—and that includes the multimedia-authoring users referred to in the previous paragraph—they are apt to see written expression and information acquisition ("finding out about ideas and information") as one of the primary objectives of their instructional use of computers. Overall, despite the fact that teachers' objectives were measured generally, without reference to particular types of software, Table 13 shows distinct patterns among the frequent users of different types of software. For example, nearly one-half of multimedia-authoring software users valued the goal of students presenting information to an audience, but frequent users of many other types of software were less than half as likely to prioritize that objective. Apart from obvious

connections, such as between electronic communications objectives and student use of e-mail software, associations were evident between collaboration objectives and both graphics software and multimedia authoring, between a skills-mastery orientation and spreadsheet/database activities, and between information analysis goals and use of three types of software—spreadsheets/databases, electronic mail, and simulation and microworld exploration programs.[14] Thus, not surprisingly, teachers' choice of software reflects their instructional goals and perspectives. This relationship will be explored in much more detail in a future report.

STUDENT COMPUTER USE FOR SCHOOL WORK ON THEIR OWN TIME

Although teachers may have their most direct effects on students' learning during class time, teachers also affect how much effort students take to do school work at other times—before and after school and at other times away from the school building. We asked teachers whose students use computers during class what proportion of the students (in their selected class) "do work for this class at other times," that is, while at school and outside of school. Across all teachers in the probability sample who assign computer work to their selected class, 25% say that all or most of their students have done computer work on at least several occasions outside of class time while at school and about the same number (28%) say that all or most students have done class work at home or other places away from school. These two types of out-of-class activities are correlated; a majority of teachers who reported one type of activity also reported the other.

Teachers who reported that students did out-of-class-time computer work differ from other teachers in terms of which subjects they taught, the overall level of student achievement in their class, the socio-economic level of the school's population, and according to which objectives they had for student computer use. Thus, student characteristics, teaching responsibilities, and approach to computer use all affect the likelihood that students will supplement their in-class computer work with time before or after school or at home, at least as measured by teacher surveys.

In terms of subject-matter, two-fifths (39%) of all science teachers who assign computer work during class reported that most or all students did computer work at school outside of class time. On the other hand, only 10% of computer-assigning math teachers did. Other secondary teachers with higher-than-average rates of reporting before- and after-school computer use included teachers of computer classes and social studies teachers. Table 14 shows not only the percent of teachers reporting most or all students doing out-of-class school-located computer work, but the percent reporting that no students did this at all. Besides math teachers, three other groups of teachers reported limited out-of-class-time computer work by students—vocational education teachers, business education teachers, and elementary teachers of self-contained classes.

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[14] The pattern in Table 13 is somewhat different than the pattern in Table 12, and several reasons are likely contributors. First, Table 13 uses a criterion of "frequent" use of a given type of software while Table 12 is based on the percentages who use that software even occasionally. Second, Table 13 uses the purposive (reform plus high tech) samples as well as the probability sample, while Table 12 only uses the latter. Third, different statistics are used in each, for different purposes. In Table 12, the focus is on contrasting teachers who prioritize certain objectives with those who prioritize others, and leads to an effect size calculation. In Table 13, the focus is on comparing frequent users of different types of software (ignoring those who are not frequent users of any type of software) and attends to differences in the kinds of objectives these contrasting groups of frequent software-using teachers have.

TABLE 14: PERCENT OF COMPUTER-ASSIGNING TEACHERS REPORTING DIFFERENT LEVELS OF **OUT-OF-CLASS AT-SCHOOL** COMPUTER WORK (FOR THE CLASS), BY SUBJECT AND LEVEL TAUGHT

	% reporting none or few students did this	% reporting 1/4 to 1/2 students did this	% reporting most or all students did this	Total (N)
Elem. Self-Contained	44	36	20	100 (160)
Elem. Other	29	46	25	100 (54)
English	29	49	22	100 (108)
Science	32	29	39	100 (98)
Math	54	37	10	100 (53)
Social Studies	14	54	33	100 (52)
Foreign Language	13	38	50	100 (5)
Miscellaneous Academic Sec.	26	51	23	100 (47)
Computers	25	39	36	100 (43)
Business	37	47	17	100 (40)
Vocational	33	47	20	100 (32)
Fine Arts	18	55	27	100 (19)
Other Applied Sec.	13	53	33	100 (14)
All computer assigning teachers	34	42	25	100 (725)

Universe: Probability sample; teachers who used computers with students in selected class.

With respect to students using computers to do work for the class at home, more computer-assigning *English* teachers reported students doing this than any other group of teachers (48%). That is probably due to the wide accessibility of word processing software on home computers. Science and foreign language teachers were also above-average in this regard, also suggesting that word processing is the dominant school-related use of computers at students' homes. The computer-assigning teachers *least likely* to report most students engaged in away-from-school computer use for class-related work were fine arts teachers (none of them did), math teachers (5%), and vocational education teachers (10%). For two of those groups, fine arts and vocational education, that is probably due to the specialized and costly nature of the software used in those courses. For math teachers, this appears to be the continuation of the relatively low involvement of math teachers in computer work that has been evident throughout this report. It should be noted that while a majority fine arts and vocational education teachers reported *some* student computer use outside of school, 71% of computer-assigning secondary math teachers reported *no* outside-of-school use by students for math class *at all*. (See Table 15.)

TABLE 15: PERCENT OF COMPUTER-ASSIGNING TEACHERS REPORTING VARIOUS LEVELS OF **OUT-OF-SCHOOL** COMPUTER WORK FOR CLASS, BY SUBJECT AND LEVEL TAUGHT

	% reporting none or few students did this	% reporting 1/4 to 1/2 students did this	% reporting most or all students did this	Total (N)
Elem. Self-Contained	34	48	19	100 (158)
Elem. Other	20	52	28	100 (53)
English	21	31	48	100 (109)
Science	18	40	42	100 (100)
Math	71	24	5	100 (50)
Social Studies	7	63	30	100 (53)
Foreign Language	13	50	38	100 (5)
Miscellaneous Academic Sec.	20	54	26	100 (47)
Computers	27	55	18	100 (40)
Business	40	43	17	100 (40)
Vocational	43	47	10	100 (33)
Fine Arts	33	67	0	100 (17)
Other Applied Secondary	13	60	27	100 (13)
All computer assigning teachers	29	44	28	100 (718)

Universe: Probability sample; teachers who used computers with students in selected class.

In the same way that teachers' objectives for student computer work affect the types of software they have students use, so, too, do those objectives appear to affect the likelihood that students will do computer work outside of class time, at school or at home. For this analysis, we combine the "out-of-class" and the "at home, out-of-school" measure and report the overall difference (in standard deviation units) in the extent of participation by students in doing computer work for the class at non-class times between teachers who include each teaching objective among their three most important objectives and teachers who do not include that objective.

Teachers with four objectives for their students' computer use are distinctly more likely to report higher levels of student participation in out-of-class computer work done for the class. By far the highest level of participation is by students of teachers who value computers for helping students to present information to an audience (E.S. = .68). Also, though, teachers whose primary objectives include students improving their writing, communicating with other people, and finding out about ideas and information all score well above average in out-of-class student use of computers for class work. (Effect sizes all about +.40; see Table 16.) In contrast, three groups of teachers are much less likely than other teachers to report students using computers out-of-class: those whose objectives are reinforcement of skills, remediation, and students "learning to work independently." (Effect sizes all about –.50.) It is interesting that teachers who value computers to help students to work independently are much less likely than others to report students actually using computers outside of their own presence! It seems plausible that for many teachers, having students "work independently" means that they prefer students to be working quietly, not that they really want them to do independent work!

TABLE 16: RELATIONSHIP BETWEEN OBJECTIVES FOR COMPUTER USE AND PERCENT OF STUDENTS SAID TO USE COMPUTERS FOR CLASS WORK DURING OTHER TIMES (AT SCHOOL PLUS AT HOME), MEAN SCORES AND EFFECT SIZE (STANDARDIZED DIFFERENCE MEASURE)

	Use of computers outside of class for class work (scale1-5)*		
Objective	Teachers with that objective (among top three) (N)	Other computer-assigning teachers (N)	Effect Size
Presenting info to an audience	3.16 (143)	2.38 (577)	0.68
Communicating electronically	2.94 (54)	2.46 (666)	0.41
Finding out about ideas and info	2.73 (363)	2.28 (357)	0.39
Expressing self in writing	2.77 (295)	2.32 (425)	0.38
Analyzing information	2.58 (216)	2.48 (504)	0.08
Learning to work collaboratively	2.47 (189)	2.52 (531)	-0.04
Improving computer skills	2.47 (234)	2.53 (486)	-0.05
Learning to work independently	2.09 (163)	2.62 (557)	-0.46
Remediation of skills	2.06 (158)	2.68 (562)	-0.53
Mastering skills	2.12 (248)	2.75 (472)	-0.54

Universe: Probability sample, questionnaire 1 and 2, teachers who used computers with students in selected class, questionnaire versions 1 & 2

Score is average of the two measures: out-of-class at-school computer use and out-of-school computer use, where 1 = 'none or few students' 2 = '1/4 of students' 3 = '1/2 of students', 4 = '3/4 of students' and 5 = 'all students.' (Overall mean, 2.51, overall standard deviation 1.16.)

Teachers' objectives, as we have seen, tend to be accomplished by having students use specific types of software. Thus, it is not surprising that teachers who report their classes frequently using certain types of software are the same teachers who report the highest levels of participation in computer work being done outside of class time. In particular, across all school levels, the teachers reporting the most out-of-class and out-of-school participation in computer activities for their classes are those who have students frequently use four types of programs: presentation software (E.S.=.51 compared to all other computer-assigning teachers), electronic mail (E.S. = .46), multimedia authoring programs (E.S. = .44), and word processing (E.S. = .48). The high effect size for word processing is doubtlessly due to the ease with which that type of software carries over to non-supervised computer time. The equally strong relationship with out-of-class computer work for the other types of software seems more likely due to the greater engagement produced by the kinds of classroom assignments into which those types of software are incorporated. (See Supplementary Table A-7 for the accompanying data.)

PART III. TEACHER COMPUTER EXPERTISE AND PROFESSIONAL USE

TEACHER PROFESSIONAL USE OF SOFTWARE

As we showed in Table 1 of this report, about 30% of teachers *do not* have their students use computers. However, three-fourths of those non-computer-assigning teachers *do* use computers for their own professional needs—to prepare materials for teaching, to keep track of student grades, or to communicate with other teachers or parents. (So do 98% of the teachers who assign computer work to their students.)

Overall, teachers' most frequent professional uses are related to their day-to-day needs—making handouts, keeping a record of student grades, and writing lesson plans or notes. A majority of teachers use computers to make handouts for class on at least a weekly basis. Almost half of all teachers also use computers that frequently to record and calculate student grades and to make lesson plans or notes.

Teachers use computer technology less often in other ways, such as getting information from the Internet (28% do that at least weekly). Most teachers use computers at least occasionally to correspond with parents, and between 30% and 40% also from time to time exchange computer files with other teachers.

Similarly, almost one-third use camcorders, digital cameras or scanners. By Spring, 1998, nearly one teacher in five had posted student work, suggestions, or shared their opinions on the World Wide Web.

These percentages as a whole suggest that computers have become a routine tool for helping teachers accomplish their professional work. Computers are no longer just something for students to spend time on. They have become a major tool of the trade.

Teachers of some subjects are more likely to use computers professionally than are others. (See Table 17.) Math teachers, for example, are less likely to use computers in most ways than are other teachers. They are less likely to use computers for making handouts, getting information from the Internet, or translating material to electronic format. However, they are more likely than other teachers are to use computers to keep track of student grades. In contrast, teachers of computer, business, and vocational education courses use computers more for professional purposes than other teachers do. They exceed other teachers particularly in writing lesson plans, exchanging computer files with other teachers, and using camcorders, digital cameras or scanners, and also in recording grades by computer.

TABLE 17: PROFESSIONAL USES OF COMPUTERS, BY SUBJECT-LEVEL

	English	Social Studies and Science	Math	Comp-Bus-Voc	All Other Sec.	Elem-entary	All teachers
% of teachers who use of computers for the following weekly or more often							
Making handouts	79	71	51	74	63	61	66
Student grades	51	59	66	63	40	32	49
Writing lesson plans/notes	49	51	33	60	39	30	42
Get information from Internet	26	33	14	22	36	29	28
% of teachers who use of computers for the following occasionally or more often							
Corresponding with parents	66	60	64	70	65	78	68
Exchanging files w/other teachers	38	42	29	55	38	36	39
Use camcorders, digital cameras, or scanners	41	33	14	47	29	29	29
Posting on Web	22	19	11	24	24	14	18
(N)	(322)	(514)	(257)	(251)	(305)	(536)	(2,185)
Mean number of professional use criteria passed							
All teachers of that subject	3.7	3.7	2.8	4.1	3.4	3.1	3.4
Teachers whose students use computers frequently	4.1	4.5	2.6	4.5	4.4	3.8	4.1
(N)	(73)	(84)	(28)	(173)	(71)	(248)	(677)
Teachers whose students use computers occasionally	3.8	4.0	3.4	4.0	3.4	2.9	3.5
(N)	(181)	(262)	(110)	(62)	(149)	(224)	(988)
Teachers whose students do not use computers	4.2	3.7	3.2	*	3.2	3.3	3.4
(N)	(54)	(138)	(97)		(73)	(46)	(420)

Universe: All teachers in probability sample.
*N too low.

In general, teachers who use computers more frequently with students also use computers more for professional purposes. This is not, however, true for mathematics teachers. Math teachers whose students use computers frequently (41+ times) themselves use professional applications at about 75% of the rate that math teachers whose students use computers less often do. This is the opposite of the pattern for most other subjects, as shown in Table 17.

Frequent computer-assigning teachers are most different from non-computer assigning teachers in their greater use of searching the Web for resources for use in teaching, in using scanners, digital cameras, and

camcorders as teaching resources, and in posting information on the Web. (See supplementary Table A-7.) One professional application, interestingly enough, is used somewhat more by non-computer-assigning teachers than by those who give students frequent computer assignments—keeping track of student grades. This appears to be a simple-to-understand application that requires little computer expertise. Yet, once teachers find other ways to help them in their professional work, they may put aside this particular application.

TEACHER SELF-REPORTED EXPERTISE WITH COMPUTERS

A computer is a fairly complex piece of electronic equipment. In part, it is complex because its functions are so varied. Although for decades teachers have had to operate equipment such as movie projectors, slide projectors, and VCRs to fulfill their teaching role, the skills required to successfully operate computers are far removed from most other competencies required of teachers—for example, classroom management, student assessment, organizing materials and planning lessons. Still, if teachers are to successfully use computers for their own professional needs and to oversee how students themselves use computers to fulfill classroom assignments, teachers will need to have certain levels of expertise in basic computer operations.

Our survey asked teachers to rate their skill level for eight different computer tasks, from displaying the directory of a computer disk to developing a multimedia document. The percentage of teachers who reported that they knew how to do a particular computer task varied from 75% who said they could display a disk's directory to only 18% who said they could develop a multimedia document. In addition, nearly three-quarters (71%) said they could copy files from one disk to another, three-fifths could use a Web browser (63%), about one-half (48%) said they could imbed graphics into a word processor document, two-fifths (40%) could create a new database and establish fields and screen layouts, and one-fourth (26%) could prepare a slide show using presentation software. Of course these skills were not actually tested, but they are the teachers' self-reported presentation of their sense of competency in these areas.

In a second survey question, we asked teachers to rate their expertise on each of three different computer platforms: Windows/DOS, Macintosh, and Apple II. Overall, a majority of teachers (59%) felt that they were at least "very experienced" on at least one of the computer platforms, and 11% considered themselves "expert" on at least one platform. Many teachers have had sufficient experience to consider themselves "very experienced" (or better) on more than one platform (22%), but few felt they were expert on more than one (3%).

Generally, secondary teachers, particularly high school teachers, reported having higher levels of computer skill and platform expertise than did elementary school teachers. (See Table 18.) Overall, for example, high school teachers, even including those who did not have their students use computers, reported having about 4 computer skills out of the seven asked about compared to 2.6 skills for the average elementary teacher. Also, they were twice as likely to claim expertise on a computer platform (14% vs. 6%). Within the secondary teaching ranks, not surprisingly computer teachers were most likely to claim platform expertise (32%). The least likely were math teachers (8%) and teachers of "other applied" subjects (5%). In terms of self-reported computer skills, elementary teachers reported fewer of them, on average, than any group of secondary subject-matter teachers.

TABLE 18: TEACHER COMPUTER EXPERTISE BY SUBJECT-LEVEL

	% very experienced (or expert) on any platform	% expert on any platform	Mean computer skills (# criteria of 7 met)	% very experienced or expert in Mac	% very experienced or expert in Win
Elementary self-cont.	56	7	2.7	31	27
Elementary other	45	4	2.5	37	17
English	61	14	3.2	35	35
Science	66	12	4.0	31	39
Math	56	8	3.3	23	36
Social studies	57	12	3.6	28	32
Foreign language	51	17	2.8	38	22
Mixed Academic Sec.	62	13	3.6	37	41
Computers	90	32	5.2	31	74
Business	85	15	5.1	20	80
Vocational	51	12	3.7	21	37
Fine arts	65	15	4.3	48	27
Other Applied Sec.	48	5	3.1	30	16
Elementary	53	6	2.6	32	24
Middle school	57	12	3.4	29	33
High school	66	14	3.9	32	42
All teachers	59	11	3.4	31	35

Universe: All teachers in probability sample. For N's, see Table 1.

In terms of the platform on which teachers are most experienced, about the same percentage of teachers feel themselves either "very experienced" or "expert" in using the Macintosh (31%) as feel that way about using Windows or DOS systems (35%). (Nine percent say they are very experienced or expert on both.) Among teachers who assign computer work to students, there is a similar pattern: 34% are very experienced or expert on Macs compared to 36% having that level of experience with Windows. Only one- fifth of all teachers (and 24% of all computer-assigning teachers) report being very experienced on Apple II series computers.

Expertise on Windows/DOS systems varies by school level, with nearly twice the percentage of high school teachers rating themselves "very experienced" or better as did elementary teachers (42% vs. 24%). In contrast, the presence of Macintosh expertise is quite even across the three school levels—roughly 30% of teachers at all levels claim that level of experience. By subject, there are sharp differences favoring Windows expertise among computer teachers and business education teachers—teachers who generally have the most technology available and whose students use computers the most frequently. In business education, four times as many teachers report being very experienced or expert on Windows/DOS as on Macintosh systems. Among computer teachers, the ratio is about 2.5 to 1.

However, teachers who call themselves "very experienced" or "expert" on the Macintosh system actually report having somewhat more computer skill in general, and they are more likely to have some specific advanced competencies than teachers who call themselves "very experienced" or "expert" on Windows computers. This becomes apparent only when one holds subject-matter "constant" because Windows-expert teachers, concentrated in the computer and business education fields, do tend to report more computer skills overall.

Elementary teachers and secondary computer or business teachers who are very experienced or expert Macintosh users report having about one-half an additional skill, making them one-fifth to one-fourth a standard deviation higher than very experienced or expert Windows users. (See Table 19.) In contrast,

among very experienced secondary academic teachers or secondary teachers in other applied fields there were no skill differences by platform.

When we examine specific computer competencies, for most of the more advanced individual computer skills, a slightly higher percentage of very experienced Macintosh-using teachers than Windows users report having that competency. Of the 20 individual comparisons in the bottom part of Table 19, seventeen favor Macintosh users and only two favor Windows users. Still, only one difference was really sizable—the higher proportion of very experienced Mac-using computer and/or business education teachers who report being able to develop multimedia documents (73% vs. 42%). But of the five specific skills in Table 19, only using a World Wide Web search engine failed to show a difference favoring the experienced Mac users.

TABLE 19: COMPUTER SKILLS REPORTED BY TEACHERS VERY EXPERIENCED OR EXPERT ON EACH PLATFORM, BY SUBJECT/LEVEL GROUP

Platform on which teacher was very experienced or expert	Elementary Teachers	Secondary Academic Subjects	Secondary Computer and Business Education	Secondary Other (including vocational)
Mean Number Of Computer Skills				
Macintosh	4.32	4.96	6.28	5.26
(N)	(423)	(893)	(108)	(113)
Windows	3.87	4.83	5.69	5.25
(N)	(280)	(814)	(196)	(116)
Difference (st.dev 2.24)	+.45	+.13	+.59	+.01
Percent Reporting Specific Skill				
% that can create a new database, establishing fields and screen layouts				
Macintosh	50	64	93	75
Windows	42	62	85	67
Difference	+9	+2	+8	+8
% that can embed graphics into a word-processor document				
Macintosh	69	74	97	84
Windows	62	73	92	79
Difference	+7	+1	+5	+4
% that can prepare a slide show using presentation software				
Macintosh	32	49	82	56
Windows	25	47	69	56
Difference	+6	+2	+12	–1
% that can use a World Wide Web Search Engine				
Macintosh	73	85	90	79
Windows	71	85	85	88
Difference	+2	0	+5	–9
% that can develop a multimedia document using Hyperstudio or similar authoring software				
Macintosh	36	37	73	44
Windows	31	30	42	43
Difference	+5	+7	+32	+1
(N) Macintosh	(422)	(892)	(108)	(113)
(N) Windows	(279)	(813)	(196)	(116)

Universe: Both probability and purposive samples. Teachers giving self-ratings of "very experienced" or "expert" on platform involved.

Teacher Computer Expertise and Having a Computer at Home

Many more teachers have a computer at home than have one in their classroom. (80% have a computer at home, compared to only 51% having one in their own classroom.) The same is true for modems used for Internet access: 59% of teachers had one at home in 1998 compared to 39% having one in their classroom. Because most teachers do much of their class preparation work at home, one would expect

that teachers with home computers would also report more professional use of computers and greater computer expertise overall than those without a home computer. The truth is that while having a computer at home does not "make" you an expert user, *not* having one makes it extremely unlikely that you will consider yourself to be an expert. Only 25% of all teachers who have had a home computer for more than 10 years believe themselves to be expert on at least one computer platform. But only 3% of teachers who do not have a home computer at all give themselves that designation.

The longer the teacher has had a home computer, the more likely they are to report being an expert user of one type of computer and also the greater number of distinct computer skills they report having. For example, teachers who have been home computer owners for more than a decade report an average of 4.8 of the seven computer skills, those with 7 to 10 years of home computer experience report 3.8 skills, the 4-6 year home users average 3.5 skills, the relatively new home computer users average 3.0 skills, and those without a home computer report only 2.1 computer skills. There is a similar, very regular relationship between years of home computer ownership and the number of professional use criteria met by the survey responding teacher, going from 4.6 types of professional use for the longest-duration owners to 2.1 for the non-owners. Overall, the number of years of home computer presence is correlated +.37 with both measures of computer expertise and +.32 with variety of professional uses.

Teacher Computer Skill and Expertise and their Use of Computers

The most expert teachers, not surprisingly, typically make the most use of computers in their professional work. Even among teachers of the same groups of subjects, the differences between the most computer-skilled and the least-skilled teachers are substantial. For example, among secondary academic subject teachers, those who report having 4 or 5 of the computer skills we asked about also used computers professionally in half-again as many ways as teachers who had 3 or fewer computer skills (4.1 vs. 2.6).[15] The academic secondary teachers who reported having 6 or all 7 computer skills (about one-fourth of all academic secondary teachers in the combined probability-purposive sample) used computers professionally in even more ways (5.2). The same was true for elementary teachers (4.7 uses for the most broadly skilled compared to 2.5 for the least skilled).

Having more computer skills was also associated with having students use computers more frequently and in more ways. For most subject-matter groups, among the teachers who assigned computer work to at least one class, the greater the number of computer skills self-reported, the more often they used computers with their students (in their sampled class). This was most clearly true for vocational education teachers, secondary teachers of mixed subjects, and English teachers. In those subjects, teachers who assigned more computer work also knew more about computers themselves; those who assigned less work, knew less. That was *not* true, however, for math teachers or for foreign language teachers (nor for computer teachers or business education teachers, most of which reported high computer use and high personal computer skill). In those subjects, teachers who assigned more computer work professed no greater knowledge about how to use computers than did those who assigned less. (The first column of Table 20 shows correlations between teacher computer skills and frequency of assigning computer work.)

[15] This is based on a scale which counted weekly or greater use of computers for keeping grades, making handouts, writing lesson plans, and getting information from the Web, and occasional (or greater) use for parent correspondence, use of camcorder/scanner/cameras, exchanges of files with other teachers, and World Wide Web posting.

TABLE 20: CORRELATION BETWEEN NUMBER OF COMPUTER SKILLS REPORTED AND EXTENT OF USE OF EACH TYPE OF SOFTWARE, BY SUBJECT/LEVEL

	(N)	Freq. of student use in sampled class	Word Proc.	CD-ROM Refer-ence	World Wide Web	Skill practice games	Graph-ics	Simu-lation/ Explo-ratory	Spread-sheet/ Data-base	Pres-entation s.w.	Multi-media	E-mail
Elem. Self-Cont.	(484)	.24	.30	.22	.28	.08	.25	.16	.19	.28	.31	.21
Elementary Other	(167)	.05	.23	.02	.16	.02	.19	.16	.16	.19	.29	.15
English	(407)	.33	.24	.19	.32	.12	.25	.05	.15	.33	.26	.24
Science	(377)	.28	.14	.10	.10	-.03	.05	.20	.26	.40	.15	.14
Math	(325)	.05	.30	.20	.29	-.09	.23	.08	.26	.26	.21	.13
Social Studies	(212)	.21	.25	.26	.41	-.03	.05	.25	.25	.33	.34	.21
Foreign Lang.	(59)	-.14	.10	-.08	.13	-.03	-.06	-.37	.03	.15	.14	.27
Mixed Academic Secondary	(191)	.41	.34	.24	.27	.05	.11	.19	.36	.30	.29	.17
Computers	(136)	.00	.03	.02	.12	-.11	.16	.11	.17	.33	.35	.27
Business	(90)	-.01	.15	.12	.44	-.09	.28	.08	.37	.38	.10	.14
Vocational	(67)	.48	-.11	.04	.02	-.42	.25	.15	.15	-.19	.07	-.28
Fine Arts	(70)	.26	.17	.17	-.02	-.05	.44	.12	.04	.23	.39	-.15
Other Applied Secondary	(55)	.22	.21	.31	.26	.18	.28	.07	.20	.35	.40	.12

Universe: Probability and purposive samples; computer-assigning teachers.

Teacher personal skill in using computers was especially associated with having students use certain kinds of software—most commonly, presentation software and multimedia authoring software. However, the patterns of correlation coefficients differed by subject, as Table 20 shows. The most technically skilled social studies teachers, for example, had their students use Web browsers more than less computer-skilled social studies teachers did, but among science teachers, Web use did not vary by teacher computer skill. In general, it appears that for any given group of subject-matter teachers, the higher correlations between teacher computer skill and student use of that type of software were for those applications that might be seen as being on the leading edge of computer use in that subject. Thus, the highest correlations for math teachers were for word processing software, Web browsers, spreadsheets and presentation software. For science teachers, teacher computer skill was most related to use of spreadsheets and presentation software. The only high correlation for foreign language teachers was for electronic mail use. And so forth.

If we try to compare whether computer skills are more closely associated with increased professional use or increased instructional use, in correlational terms, the relationship is clearly strongest for professional use, particularly when expertise is measured by the number of different computer skills they reported having. The correlation between number of computer skills and variety of professional use is almost twice as large as that between skills and variety and frequency of student software use (r=.52 vs. r=.29).[16] Thus, computer skill translates much more directly into professional use than into instructional use.

We can see that fact more clearly when we look at particular skills and corresponding student software use. Even if teachers themselves are skilled in a particular type of software, that is not a guarantee that they will have their students use that software. For example, although one-fourth of teachers report knowing how to "prepare a slide show using presentation software," only 34% of that group (and 6% of other teachers) say that they have had students use presentation software on three or more lessons. Similarly, only 32% of teachers who feel skilled in developing a multimedia document using Hyperstudio

[16] There is a three-fold difference in r-squared, .09 vs. .27.

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or other authoring software have their students do so. Even in the case of Web use and word processing use, teacher skill does not guarantee use in teaching. Only 41% of the teachers who report they can use a Web search engine actually assign students to use the Web, and only 60% of teachers who report being able to imbed graphics into a word processor document also report assigning their students to use word processing.

Some computer skills suggest a greater readiness to have students use computers in a variety of ways. In particular, teachers who feel capable of developing a multimedia document using Hyperstudio or similar authoring software on average have their students use computers more frequently and with a greater variety of software. This is independently true for teachers of almost every subject, and for most subjects, multimedia-authoring-capable teachers have students use computers more and with a greater variety of software than do other teachers teaching the same subject. (See supplementary Table A-8.) A second computer skill associated with a teacher's having students use computers more and with greater variety is "preparing a slide show." In particular, elementary teachers, English teachers, and secondary teachers of mixed academic subjects who feel able to produce slide shows using presentation software are among the most active computer-assigning teachers in their subject. In sum, there seems to be a clear order of difficulty among computer skills that relates to the variety of ways that teachers are able and willing to oversee student computer use. In other words, whether or not the teacher knows how to use a Web browser doesn't have much of an effect on whether they use a type of software with students. But some skills such as producing a slide show or a multimedia document clearly are indicators of a teacher's ability and interest in having students use computers in a variety of different ways and on a relatively frequent basis.

Teacher Computer Skills and Expertise and their Objectives for Student Computer Use

The computer skills that teachers hold, both specific skills and their overall expertise, are also related to the objectives that they prioritize for their students' computer use. In other words, teachers who choose certain objectives as most important are more computer-skilled on average than those who choose other objectives. Table 21 shows the average number of computer skills reported by teachers who selected different objectives as primary, separately for elementary-level teachers, secondary academic subject-matter teachers, and so on. On average, the most computer-skilled teachers are those who value computers for their role in helping students learn to make presentations to an audience, to communicate better, and to analyze information. By an even larger margin, teachers who see remediation as one of their most important objectives for using computers with students are *less* skilled computer users than teachers who have other objectives. For example, the average elementary level teacher who selected "present information to an audience" as one of their three main objectives reported having about 4.4 skills compared to just 2.6 among teachers choosing remediation as a primary objective. That difference, as shown in Table 21 is roughly three-quarters of a standard deviation.

TABLE 21: MEAN NUMBER OF TEACHER'S COMPUTER SKILLS
BY TEACHER'S PRIMARY OBJECTIVE FOR STUDENT COMPUTER USE

	Elementary	(N)	Secondary Academic	(N)	Secondary Computer and Business	(N)	Secondary Other (inc. Vocational)	(N)
Communicate electronically	3.4	(72)	4.6	(129)	*		*	
Present information to an audience	4.4	(148)	4.3	(389)	6.5	(34)	4.8	(61)
Analyze ideas & information	3.2	(119)	4.5	(537)	5.5	(68)	4.0	(50)
Learn to work collaboratively	3.1	(183)	4.4	(352)	5.8	(71)	4.2	(53)
Find out about ideas and information	3.3	(435)	4.2	(834)	5.5	(65)	4.5	(106)
Improve computer skills	2.8	(289)	4.2	(311)	5.5	(136)	4.8	(66)
Learn to work independently	2.2	(125)	3.8	(279)	5.6	(89)	4.7	(67)
Express oneself in writing	3.2	(466)	4.0	(654)	5.0	(42)	4.1	(51)
Master skills (reinforcement)	2.6	(256)	4.0	(332)	5.4	(131)	4.0	(69)
Remediation of skills	2.7	(267)	3.2	(207)	*		*	
Standard Deviation	(2.2)		(2.2)		(1.7)		(2.3)	

Universe: Probability and purposive samples; teachers who use computers with their selected class.
* N less than 30

The seven computer skills can be ranked according to which ones are differentially held (reported) by teachers with different objectives versus which ones are reported about equally frequently among teachers with different objectives. (See supplementary Table A-9.) In particular, the ability to use a World Wide Web search engine, although common among teachers regardless of their objectives for student computer use, is reported by more teachers who selected either information-related objectives ("find out" or "analyze") or communications-related objective ("communicate electronically" or "present to an audience") than by those who valued skills-related objectives (skills-mastery or remediation). Similarly, multimedia document creation skills are reported by more than a third of teachers prioritizing objectives such as collaboration and presentation to an audience, but only by 12% of teachers favoring remediation uses of computers. The same pattern is found when we consider which teachers are "very experienced" on both Macintosh and Windows platforms or "expert" on one of them: the teachers most likely to be so have "electronic communications" as one of their main objectives for student computer use, followed by those who want students to analyze data or present information to an audience. The least likely to be very experienced across platforms or expert in one are teachers valuing remediation objectives and those valuing computers for helping students to work better independently.

Finally, we examined whether computer-assigning teachers who are very experienced or expert on Macintosh platforms differ from teachers with similar expertise on Windows platforms in the kinds of objectives they have for student computer use. Because teachers' objectives are related to the subject and level they teach and computer platform is as well (to a lesser extent), we did some analysis of teacher objectives within specific subject areas. Some subjects show larger differences than others in the objectives for computer use held by Macintosh and Windows platform-knowledgeable teachers. The largest differences are among English teachers and the combination of computer teachers and business education teachers. The smallest differences were for social studies teachers and other applied secondary teachers.

Across all subjects, and generally within them as well, Macintosh-knowledgeable teachers were more likely to value having students use computers to present information to an audience, to find out about ideas and information, and to express themselves in writing. Windows-knowledgeable teachers were more likely to value computers for their help in having students master skills, computer skills in particular as well as subject-matter skills, and to work independently. In addition, among English teachers and computer/business education teachers, those most experienced or expert in the use of the Macintosh were

more likely than the Windows-experts to have "students learning to work collaboratively" as an objective. Windows-expert (or very experienced) English teachers were more likely than Mac-experts to use computers to assist in the remediation of skills not learned well. Lastly, among computer and business education teachers, the Mac specialists were more likely than the Windows specialists to state the value of computers for students learning to communicate electronically with other people. All of these differences were close to or greater than 10 percentage points, as shown in supplementary Table A-10.

Major Software Use Clusters Associated with Expert Computer-Using Teachers and Teachers Holding Objectives Correlated with High Levels of Out-of-Class Student Computer Use

Earlier in this report, we introduced a set of 30 clusters of computer-assigning teachers, 10 at each of three school levels. Each cluster represents a group of teachers whose pattern of software use by students during class time was relatively similar to one another and distinguishable from that of other teachers at the same school level. In the earlier section we showed how a plurality of computer-assigning teachers at each school level (30% of all teachers or more than 40% of all computer-assigning teachers) could be described as "limited users," but that there were as many as nine distinct patterns of software use that other teachers followed at each school level. We indicated how teachers in some clusters focused on a single type of software, while other clusters reflected more diverse software use patterns that were, nevertheless, distinct from one another. We also suggested that overall frequency of student computer use was distinguishable from diversity of software used, and we classified some teachers' pattern of assigning computer work as "focused but frequent" while others could be seen as "diverse but not frequent." Finally, we showed how teachers of some subjects were clearly over-represented in certain clusters and under-represented in others.

Since that point in the paper, we have introduced other aspects of teachers' practices—the objectives they have for student computer use, the ways in which they use computers for professional functions, and the computer skills and platform-specific expertise they possess. Each of those is also a dimension on which clusters of teachers might distinguish themselves. Those aspects, along with other basic conditions of teachers' practice, such as the socio-economic background of their student enrollments, provide a way to help us further characterize different modal patterns of teaching with computers.

As a summary clarification, the clusters were *defined* on the basis of the pattern of frequency of student software use across 10 types of software as reported by the teacher. Each of the other dimensions by which we characterize a given cluster comes from the *correlation* between that pattern of software use and these other dimensions of practice or teaching conditions. The principal purpose of this analysis is exploratory. In subsequent reports in this series, as we examine other aspects of teachers' work environments, personal background, personal pedagogy, and orientation towards the teaching role, we will learn which of these various aspects also distinguish teachers in terms of their "cluster"–i.e., the pattern of software use which they bring to their instructional activities.

All of the contrasts that we have uncovered so far are included in Tables 22, 23, and 24, one for each of the three school levels. As in the earlier discussion, rather than characterizing each one of the 30 clusters of computer-assigning teachers, we will limit commentary to certain contrasts. In particular, we will focus on characterizing those clusters that contain the teachers who are most "accomplished" in their computer use—that is, teachers with generally high levels of computer skill and professional software use and whose objectives for computer use appear to result in more out-of-class class-related student computer use (having primary objectives for students of presenting before an audience, communicating with other people, finding out ideas and information, and improving written work). We will also comment on the specific software that these "most accomplished teacher-clusters) clusters identified as most valuable in their teaching practice.

Upper-Elementary Grades Clusters

At the elementary school level, the 35 teachers in Cluster 1-10 (see Table 22) clearly stand out on all of the criteria we selected for attention. Cluster 1-10 teachers are very high on general computer skills; they report high levels of platform-specific experience; they are extremely high on professional use, and they have distinctively strong objectives in exactly the four areas identified earlier as related to high levels of out-of-class student computer use. (Not surprisingly, they have the highest level of out-of-class computer use by students of any cluster except for one high-school cluster.) These teachers' students use computers very frequently, using nearly every single type of software our survey inquired about. As a group, by a large margin, the single software title they most often mention as "most valuable" for their students is the multimedia authoring program, Hyperstudio (two thirds named it as most valuable). They are relatively rich in classroom computer resources, with 38% of them (still not a majority) having at least a 1:4 ratio of computers to students in their room. However, they also use computers outside their classroom, with 50% reporting both classroom and lab settings as equally central to their students' work. They do teach in economically advantaged schools, but their students are not particularly high in attributed "ability" or prior achievement.

Subsequent examination of this group and the others will reveal the way these teachers might or might not differ from others in terms of their personal teaching philosophy, the characteristic way that they organize classroom learning, their orientation towards their own classroom versus their teaching peers both at their own school and beyond, the kinds of changes in their approach to teaching that they report having made over the past three years, the degree of support that exists for teachers' computer use at their school, the extent of formal training opportunities provided to them, the types of pressures which these teachers feel, or don't feel, how much technology their school has as a whole, the extent of a school-wide emphasis on instructional reform and the level of administrative support for computers and for reform, and their own personal educational background and teaching experience.

A second elementary level cluster of interest is Cluster 1-5, which we call "focused multimedia." The 52 teachers in this cluster are higher on measures of personal computer expertise and professional use than any other elementary cluster except for the just-discussed Cluster 1-10, even though the extent of their students' computer use is not quite as great as some others. These teachers' main emphasis is on student development of multimedia products, along with word processing, and exploratory use of most other types of software. They disproportionately include two of our targeted objectives for computer use–writing and presentation to an audience. Again, and not surprisingly given their objectives, it is Hyperstudio that is far and away their most frequently named "best" software program for students with thirds of the teachers in this cluster naming it to be so. This group's practice appears to suffer from not having enough computers in their own classroom (33% of them have none at all), but they use whatever computer resources are available to them. Their students disproportionately have access to Macintosh computers, but compared to other teachers they are more likely to report having students work one-on-one at computers rather than in pairs (which may be explained by their higher-than-average choice of "analyzing information" as a prime objective for computer use. As we explore other parts of our data, it will be interesting to learn the advantages and disadvantages these teachers bring to their computer-use practice. We suspect that among their advantages are excellent pedagogy, but that poor school support constrains them from carrying out a more extensive computer-based practice.

Middle Grades Clusters

Although three of the middle grades clusters contain teachers who are clearly expert and well-experienced in computer use (and two more clusters that approach that level), on the criterion of "objectives associated with out-of-class student use," none of the clusters seem as remarkable as Cluster 1-10 did at the elementary level. (See Table 23.) Cluster 2-8 comes the closest. In this group, teachers

TABLE 22: UPPER-ELEMENTARY GRADES CLUSTERS: CHARACTERISTICS OF COMPUTER USE, STUDENTS AND TEACHERS

Cluster	Name	3 Measures of Frequency of Computer Use**	Software Use	Best Software Named	Objectives for computer use	Where primarily use	Computer to student ratio	Solo vs. pairs	Student Platform	Student Ability***	Out of Class Use***	Schl. SES ***	Teacher Comp Skills***	Teacher Exper-tise***	Prof'l Use***
1-0	non-users	none	none						none				– – –	– –	– – –
1-1	limited use	1, low2, low2 – focused, infrequent use	occasionally games	Accel. Reader (12%)	not writing	more in class					–		– –	–	–
1-2	word processing	2,2,2	word processing	ClarisWorks (24%)	writing	more outside			more mac (61%)			+			
1-3	resource	2,2,2	1: CD-ROM, word processing; 2: games	ClarisWorks (14%)	find out	more in class	in: few with none (7%); and few with 6:1 or better (12%)		mixed (46%)		+		–		
1-4	typical	high2, high2, low4 - primarily weekly use	games, graphics, word processing all equally, nothing else	MS Word (17%) ClarisWorks (13%) Oregon Trail (12%)	(rel. low on find out)	more outside	in: many with none (29%) any: 81% with 2:1 or better (even though only 3% had 4:1 in class)								
1-5	focused multimedia	3, 3, 3	1: multimedia; 2: word processing, wide range of exploration	Hyperstudio (66%) ClarisWorks (24%) Writing Publish. (18%) Accel. Reader (16%)	writing, presentation (rel. high on analyzing) not computer skills, independent work	overwhelm-ingly in both places (81%)	in: many with none (33%)	more solo (66% vs. 46%)	high mac (67%) (n=21)		++ + (n=5)		++	+	++
1-6	info. mix	3, high3, 3	1: web; 2: word processing, CD-ROM; some games, occasionally e-mail	Netscape (18%) ClarisWorks (13%)	writing, finding out not skills										+
1-7*	multimedia info. n=10	3, high1, high1 - broad but not frequent	1: multimedia, 2: CD-ROM, graphics, simulation; little word processing	Hyperstudio (47%) Netscape (28%) Groliers Ency. (20%)	skills (rel high on analyze)	overwhelm-ingly outside only (71%)	in: 75% had great ratio (4:1 or better) any: 100% had 2:1 or better	more pairs (64% vs. 45%)	win (67%) 0% mac (n=5)	++	++ +			+	
1-8	core frequent	high3, 3, 3	1: word processing, games, simulations, CD-ROM; some web	ClarisWorks (21%) Oregon Trail (11%)	find out not remediation										
1-9	core graphics	high3, 2, 4 – broad, primarily weekly	1: word processing, graphics, CD-ROM, games; some simulations	ClarisWorks (23%) Accel. Reader (13%) MS Works (13%) Reader Rabbit (12%)	(rel high on analyze) not computer skills or independent work	heavily in both places (52%)		more variation within classes ("solo + pairs"), less pure solo	high mac (71%) (n=17)	++ +	++ +		+		++
1-10	high end	4, 4, 4 – very high	1: word processing, CD-ROM, web, presentation, multimedia; substantial games, simulations, graphics	Hyperstudio (66%) ClarisWorks (28%) Writing Publish. (12%) KidPix (11%)	writing, finding out, presentation, collaboration not skills, remediation, or independent work	heavily in both places (50%)	in: rel. high % with 4:1 or better (38%)	more variation within classes ("solo + pairs"), less pure solo	(n=19)		++ ++	++	++ +	++	++ ++

*This cluster tends not to be self-contained, but other elementary.
**Measures score from 1 to 4.
***Each (+) represents 1/4 to 1/2 a standard deviation above the mean. Each (–) represents 1/4 to 1/2 a standard deviation below the mean.

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disproportionately chose "finding out about ideas and information" and "presenting information to an audience" as principal objectives for student computer use, and clearly did not select skill mastery or remediation. Although not quite as computer-knowledgeable or active as some other middle grades clusters (particularly 2-9 and 2-10), teachers in this cluster are more likely to be academic subject-matter specialists (particularly in English and science) rather than computer or fine arts teachers, as in Cluster 2-9, or "mixed academic teachers," as in Cluster 2-10. Their choice of software emphasizes word processing (ClarisWorks is clearly the most popular) and the World Wide Web (Netscape), while other software is used in more exploratory ways. (Only 11% mention Hyperstudio, for example.) As with Cluster 1-5, their students disproportionately have access to Macintosh computers, and teachers seem to use both classroom and shared space facilities for their students' computer work.

The other two middle grades clusters with high levels of teacher computer expertise (2-9 and 2-10) are mainly advantaged in terms of access to computers. A majority of teachers in Cluster 2-9 had at least a 1:4 ratio of computers to students in their classroom, while 83% of Cluster 2-10 teachers had a 1:2 ratio somewhere in the school, better than most other groups. Both of these clusters of teachers used a richer mix of software, more frequently, than did teachers in Cluster 2-8. However, despite of their breadth of software use, Cluster 2-9's teachers appear to emphasize the "skills" involved in learning and using software and definitely, for example, do not prioritize "improving written expression" as a goal of their computer use. The three software titles most often named as "most valuable" for this group were Microsoft Office (which is primarily a high-school-and-older package), Netscape, and Hyperstudio—quite a diverse set. The 2-9 teachers also exhibit some confusion between intention and practice, as they selected "learning to work collaboratively" more than other teachers did, but they also most often reported assigning students to computers on a one-on-one basis rather than having them work in pairs. Whereas teachers in Clusters 2-8 and 2-10 both report relatively high levels of out-of-class computer use by students, the teachers in Cluster 2-9 report only average levels of such use. Cluster 2-10 teachers, like Cluster 2-8's, name ClarisWorks and Netscape as their most valued software for their students.

High School Clusters

Five clusters of high school teachers show high levels of computer expertise and use computers professionally more than other high school teachers do. (See Table 24.) A typical Cluster 3-4 teacher is a science teacher in a middle class community whose students mainly use computers in pairs, but relatively infrequently, to find information on Web sites. Not surprisingly, Netscape is the program most often mentioned as "best" in this cluster. However, teachers in Cluster 3-4 are less likely than average to report student use of computers for schoolwork outside of class. In contrast, Cluster 3-7 teachers have students who are *more* likely than average to use computers outside of class. A Cluster 3-7 teacher is typically an English teacher whose above-average ability students use computers in a variety of ways but distinctively by doing electronic mail. Yet, their three "favorite" programs were all word processing programs—ClarisWorks, Microsoft Word, and Word Perfect.

Cluster 3-8 is composed of English, social studies, and computer teachers whose students use a wide variety of software including word processing, Web and CD-ROM information sources, graphics output, and presentation software and who emphasize presentation objectives more than other teachers do, using primarily Macintosh computers. The software most often mentioned as best for students by these teachers are Netscape and Powerpoint. Thus, information acquisition and communication of that information are both prime uses of computers in these academically-oriented classes. Students of Cluster 3-8 teachers are among the most active in using computers for class tasks outside of the class period and outside of school.

Students of teachers in Clusters 3-9 and 3-10 have the most intensive computer experiences, primarily on Windows computers, and a majority of them are computer education or business education teachers,

TABLE 23: MIDDLE SCHOOL CLUSTERS: CHARACTERISTICS OF COMPUTER USE, STUDENTS AND TEACHERS

Cluster	Name	Teacher Subject	3 Measures of Freq. of Computer Use*	Software Use	Best Software Named	Objectives for computer use	Where primarily use	Computer to student ratio	Solo vs. pairs	Student Platform	Student Ability**	Out of Class Use**	Schl. SES **	Teacher Comp. Skills**	Teacher Exper-tise**	Prof'l Use**
2-0	non-users	Math	None	none						none				–	–	–.
2-1	limited use		1, 1, 1	very little	ClarisWorks (13%)							–				
2-2	word processing	English (bus ed over-rep)	2, 2, 3	word processing	ClarisWorks (23%) MS Works (13%) MS Word (8%)	writing	more in class			high mac (67%)		+		+	+	
2-3	games	Math (foreign lang over-rep)	2, 2, 2	games, some simulation	ClarisWorks (22%)	skills, remediation, independent work not writing or presentation		in: high % with 4:1 or better (45%) but many with none too (30%).	more solo (74% vs 56%)	high win (65%)	–	– – –	–			
2-4	exploratory	social studies primary; science secondary	2, 2, low2	CD-ROM (not highest); some multimedia, presentation, word processing	Hyperstudio (25%) ClarisWorks (13%)	finding out	more outside		more groups and other; fewer pair	high mac (65%) (n=19)	+		+	+		+
2-5	web	(computers and vocational over-rep)	2, low3, 2	web, some word processing	Netscape (30%) MS Word (12%) MS Works (11%)	finding out				more win (58%)				+	+	++
2-6	info core	mixed/other academic primary; science secondary	3, high2, high2	CD-ROM, web, word processing	Encarta (12%) Netscape (10%)	finding out not skills	heavily in both places (48%)	in: many had none (32%)	somewhat fewer solo	slightly more win		+		++		++
2-7	like elementary	computers and mixed/other academic	3, 2, high2 - broader than frequent	word processing along with CD-ROM, games, simulations, some graphics	ClarisWorks (12%)	finding out and analyzing not presentation	more in class			(n=19)			–	+		++
2-8	wp-web-broad	English and science (computer ed over-rep)	high3, 3, 3	1: word processing and web; some mix of others incl. Presentation and multimedia, spreadsheet/database and CD-ROM, graphics	ClarisWorks (44%) Netscape (29%) Hyperstudio (11%)	finding out, presentation not skills or remediation	heavily in both places (42%) or in class		more groups (13% vs. 4%)	high mac (70%) (n=23)	++	++		++ +	+	++
2-9	high graphics presen-tation	computers (fine arts over-rep)	4, 4, 3	1: graphics and presentation 2: word processing, multimedia, spreadsheet/database; some of everything else except e-mail	MS Office (16%) Netscape (14%) Hyperstudio (12%)	skills (rel. high on collaboration) not writing		in: most had great ratio (4:1 or better) (58%)	more solo (74% vs. 56%)	more win (58%) (n=16)				++ +	++ +	++ ++
2-10	high internet-broad	mixed/other academic	4, 3, low3 broad but not frequent	1: word processing, web, and e-mail; 2: CD-ROM presentation; some of everything else	Netscape (35%) ClarisWorks (23%) Word Perfect (16%)	(rel. high on elect-communication) not skills		in: most had at least 6:1 (64%) but not that many at 4:1 any: more had 2:1 or better than other groups (83%)		high mixed (30%) (n=22)		++		++ +	++ +	++ ++

*Measures score from 1 to 4. High School Clusters

**Each (+) represents 1/4 to 1/2 a standard deviation above the mean. Each (–) represents 1/4 to 1/2 a standard deviation below the mean.

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(computer teachers forming an absolute majority in Cluster 3-10). Teachers of both clusters emphasize computer skill objectives rather than academic competencies like writing or gaining knowledge or authentic accomplishment such as presenting and communicating one's understandings to reach a real-world goal. In both clusters, the most commonly named "best" software is Microsoft Office.

There are several interesting contrasts between Clusters 3-9 and 3-10. In terms of the cluster-defining statistical algorithm which distinguished contrasting patterns of software use, teachers in Cluster 3-9 involve their students in greater use of the World Wide Web and more game-playing and somewhat more spreadsheet/database work, while Cluster 3-10 teachers' students make greater use of graphics software, presentation software, and simulation software. Those distinctions are not easily interpretable.

However, we also found three other factors that quite sharply differed between the two sets of teachers. Students of Cluster 3-9 teachers are typically from somewhat lower socio-economic-status communities, they most often work individually at computers, do their work in their own classroom and do not do computer-based schoolwork outside of class time. In contrast, Cluster 3-10 students are typically high achieving students from relatively wealthy neighborhoods, they are very active in using computers for classwork outside of class time, and during class they most often work in pairs or groups in specialized computer labs.

Yet, interestingly enough, it is the Cluster 3-10 teachers who most clearly define their objectives for student computer use in terms of skills and attitudes (computer skills and learning to work independently) rather than goals of academic understandings or communicating those understandings. In fact, Cluster 3-10 teachers explicitly eschew goals such as improved student writing or information acquisition. Looking ahead to data that will be presented in more detail in a future report in this series, we also found that Cluster 3-10 teachers were far more traditional in their actual pedagogy than they were in their personal teaching philosophy and that they were particularly likely to select as disadvantages of using computers that students are not careful with the equipment and that computers let students cheat more easily.

The best picture we can get so far is that the former group of teachers, in Cluster 3-9, are providing their somewhat economically disadvantaged students with a good but conventional education in using mainstream computers, thus helping them gain technical skills valuable for economic and social mobility. On the other hand, Cluster 3-10 teachers, for all of their personal expertise about computers (by far the most knowledgeable, experienced, and professional users of computers) and despite having students with backgrounds and perceived abilities that suggest adolescents at the start of successful careers and adult lives, seem to lack a vision for how the computer skills that they provide to students can be linked closely to academic core objectives and to developing young people's talents for engaging in collaborative action to affect real-world situations.

Our analysis of teacher clusters defined by patterns of software use will be continued in future reports that examine other aspects of teachers' philosophies, teaching practices, and working conditions. This "cluster approach" serves as a sometimes-confusing, sometimes-clarifying alternative to the more conventional analysis of the interrelationships among individual variables. But it is required by the complex nature of the dimension of practice defined by the teacher's pattern of in-class student-use of computer software, and we suspect that in the long run, it will prove highly enlightening.

TABLE 24: HIGH SCHOOL CLUSTERS: CHARACTERISTICS OF COMPUTER USE, STUDENTS AND TEACHERS

Cluster	Name	Teacher Subject	3 Measures of Freq. of Comp. Use*	Software Use	Best Software Named	Objectives for computer use	Where primarily use	Computer to student ratio	Solo vs. pairs	Student Platform**	Student Ability**	Out of Class Use**	Schl. SES**	Teacher Comp Skills**	Teacher Expertise**	Prof'l Use**
3-0	non-users	math (foreign lang over-rep)	none	none						none					–	–
3-1	limited users		1, 1, 0	very little	MS Word (10%)											
3-2	elem. pattern	math math math	high1, high1, 1 - low freq.	some games and simulations	Geometer's Sketchpad (25%)	skills (rel. high on remediation) not writing			more pairs; less solo (55% vs. 37% and 28% vs. 53%)		–	– –				
3-3	graphics	vocational and fine arts (mixed/other acad over-rep)	2, low4, 3 - focused some freq. users	almost only graphics; some word processing	AutoCAD (24%) PhotoShop (13%) MS Works (10%)	computer skills (rel. high on presentation) not analyzing	more in class	any: more had 4:1 or better than others (90%)						+	+	
3-4	web	science	2, high1, low2 -rel. low freq.	web; some CD-ROM	Netscape (27%) ClarisWorks (14%) MS Works (12%)	finding out			more pairs (62%); less solo (31%)	more mixed (30%) (n=25)		–	+	++	++	++
3-5	word proc w/info	English	2, 2, 2	word processing; some CD-ROM and/or web	Netscape (16%) ClarisWorks (16%) MS Works (15%)	writing						+			+	
3-6	computer lit	computers and business	high2, 4, 3 - focused some very freq. users	1: spreadsheet/database; 2: word processing; little else	MS Works (15%) Word Perfect (14%) ClarisWorks (11%) MS Office (11%)	skills not presentation	more in class	in: over 3/4 have 4:1 or better (78%) any: more have 2:1 than other groups (86%)	more than 3/4 solo (78%)	high win (72%)		–		++	++	
3-7	internet	English (mixed/other acad over-rep)	3, high2, 2- broad more than freq.	1: e-mail 2: web, word processing little else	ClarisWorks (17%) MS Word (15%) Word Perfect (13%)	not remediation					+	+		++	+	++ ++
3-8	high use info-communicate	English, computers, and social studies	4, 3, 3 - broad more than freq.	1: word processing, web and CD-ROM; 2: presentation and graphics; occasionally other communication/ production	Netscape (39%) Powerpoint (29%) MS Word (13%)	presentation not skills or remediation		any: more have 4:1 or better than others (94%) but not 2:1		high mac (63%) (n=19)		++ +		++	++	++ +
3-9	high use computer apps in classroom	computers and business (mixed/other acad over-rep)	4, 4, low4	1: word processing spreadsheet/database; 2: presentation and web; some games	MS Office (33%) Netscape (32%) MS Word (26%) Excel (15%)	computer skills	more in class	in: almost all have 4:1 or better (89%) any: more have 2:1 than others (85%)	mainly solo (71%)	high win (75%) (n=16)		–	–	++ +	++ +	++ +
3-10	high use computer skills in lab	computers computers business	4, 4, high3	1: word processing, graphics, and presentation; 2: spreadsheet/database and simulation; some web and CD-ROM and others too	MS Office (25%) Hyperstudio (12%) Word Perfect (11%)	computer skills, skills, and independent work; not remediation, writing, or finding out	more outside	in: three quarters have none (75%) in class	few solo (29%); almost half are "other"-need explanation	all win (100%) (n=9)	++	++ ++ (n=11)	++	++ ++	++ ++	++ ++

*Measures score from 1 to 4.
**Each (+) represents 1/4 to 1/2 a standard deviation above the mean. Each (–) represents 1/4 to 1/2 a standard deviation below the mean.

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DISCUSSION AND CONCLUSIONS

Computers have been present in most schools for nearly 20 years. Until recently, their use has been limited by the relatively small number of computers compared to the number of students present. However, as shown in Report 2 in this series,[17] by 1998 the typical school had one computer for every 6 students enrolled, or about four computers per classroom if they were actually divided equally among all instructional rooms.

School computers have also had a limited impact on students because until recently, a plethora of limitations—technical ones, limitations in the variety of software and content, in notions about what should be done with computers, and in knowledge of how to integrate computer activities into teaching—all conspired to trivialize the kinds of tasks that students were asked to do with computers. In particular, students in elementary schools, and into middle school grades, primarily used computers to do skill-related drills and to play "edutainment" games. Teachers used computers to provide a welcome break from the routine of more difficult and "more important" learning. In students' secondary school experience, computers became a subject in itself, either a pull-out program of "computer literacy" provided by a specialist teacher or a whole semester or year-long course in computers, keyboard skills, computer programming, or word-processing. Computers became another set of skills that parents, students, and teachers believed to be important for students' future lives, but computer skills were seen as a ticket to the future much more than as a tool for improving current understandings and academic competence.

Our analysis of the Teaching, Learning, and Computing 1998 survey data suggests that the computer experiences that teachers provide to students are *beginning* to change, in some ways fairly dramatically, from the experiences that earlier cohorts of students had. It is *still true* that, at the high school level, a majority of intensive experiences with computers that students have are in courses outside of the academic core—most often in computer classes and business education classes. It is also still true that a majority of teachers across grades 4 to 12 either do not use computers at all with their students or do so only occasionally; the "typical" teacher provides students with fewer than ten opportunities to use computers during a school year. Nevertheless, we have found that those academic subject-matter teachers who do have their students use computers frequently, do so in ways that are different from the "traditional" focus on computer-based drills and learning games and computer "literacy."

Across the academic subjects at both elementary and secondary levels, the most common objectives that teachers have for their students' use of computers no longer are "practicing skills just taught" or "learning computer skills." Instead, the objectives most often named have to do with students gaining access to information and improving their writing. Moreover, the kinds of software that teachers report using most often with their students—word processing programs, CD-ROM reference materials, and World Wide Web browser software—confirm that what students do most often on school computers involves searching for information and ideas through electronic media and expressing themselves in writing; *not* practicing math and grammar drills, playing games, or learning computer skills as isolated skills.

Nevertheless, the activity of students gathering information and writing about it is not the whole story of how teachers direct student use of computers in schools today. Apart from Web browsers and word

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[17] Ronald E. Anderson and Amy Ronnkvist, "The Presence of Computers in American Schools," Report #2, Teaching, Learning, and Computing: 1998 National Survey. University of California, Irvine. June, 1998. http://www.crito.uci.edu/tlc/findings/computers_in_american_schools/html/startpage.htm

processing programs, most of the other specific software titles that teachers report to be most valuable for their students—*Hyperstudio*, among elementary teachers and secondary social studies and science teachers; *Geometer's Sketchpad* in mathematics, *AutoCAD* in vocational arts subjects, and *PhotoShop* and *PageMaker* in fine arts classes—are evidence that at least *some* teachers are having students use computers as productivity tools in complex projects that may involve higher-order thinking, designing a product, and explaining their ideas and constructions to an external audience.

In fact, we found that the teachers who are most technically knowledgeable about computers are the ones who are most likely to have their students use presentation software and multimedia authoring software and to have as principal objectives goals like having students use computers to help them present their ideas before an audience and to communicate with other people. Although even among the most computer-skilled teachers, objectives such as acquiring information or writing are more common than the objective of helping students to communicate information to an audience, the most computer-skilled teachers are much more likely than other computer-assigning teachers to include audience presentation among their objectives.

Many of those who support increased incorporation of computer-related activities into academic coursework argue that student engagement in doing schoolwork is improved and even carries over to times of the day when direct teacher supervision is absent. Our research has found that teachers whose objectives for student computer use include having them learn to develop presentations for audiences, communicate with other people, acquire information, and express themselves in writing are much more likely than other teachers to say that their students do work for the class using computers outside of class time (for example, at home, or before or after school). Similarly, the teachers who report the most out-of-class involvement by students in doing work for their class are those who frequently have students use *during class* one of four types of programs: presentation software, electronic mail, multimedia authoring software, and word processing programs.

Finally, it is certainly true that what makes a good computer-using teacher is more than any one thing: technical knowledge about computers helps, so does experience in using computers professionally, and it also seems reasonable to expect that an exemplary teacher has the kinds of objectives for student computer use and employs the types of software that most likely result in student engagement and thoughtful effort, outside of class time as well as during class.

At the elementary level, we identified two clusters of teachers who were strong in all of those respects. Together, those clusters of teachers represent only 5% of all teachers of the upper-elementary grades, but by having students integrate a range of academic and technical competencies into the production of multimedia products, they are helping to demonstrate what nine- and ten-year old children can accomplish using technology. At the middle grades, we also identified two strong clusters in terms of expertise, professional use, and the nature of their objectives (4% of all middle school teachers). In this case, the teachers emphasized both word processing and use of the World Wide Web, along with some use of electronic mail (in one cluster) and presentation and multimedia software. The teachers in these clusters demonstrate the integration of information acquisition with communication of that information, making learning consequential for their students and their students' audiences. At the high school level, we identified five clusters (13% of all high school teachers) where relatively high levels of computer expertise were present, but in only one of those clusters did the teachers seem outstanding in terms of having objectives for student computer use that translated into high levels of out-of-class involvement in computer work for the class. Those classes—a mixture of primarily English, social studies, and computer classes—used an array of software going beyond word processing, Web browsing, and CD-ROM use, to include presentation software (PowerPoint was second-only to Netscape as those teachers' most valued software) and other graphically-oriented

programs. Here again, these teachers demonstrated the integration of information acquisition, thoughtful writing and presentation, and concern with communicating findings to an audience.

The teachers in these highlighted clusters, although clearly a minority of teachers and even a minority of computer-assigning teachers, constitute a pioneering group of technology-knowledgeable instructional innovators. They constitute the standard for exemplary instructional computer use, and their numbers are likely to increase in the near future.

APPENDIX A. SUPPLEMENTARY TABLES

TABLE A-1: WHICH MIDDLE SCHOOL TEACHERS BELONG TO "DIVERSE-USE" CLUSTERS, "LIMITED AND SPECIALIZED USE CLUSTERS," AND "NON-USERS"?

Subject Taught	(N)	% that do not use computers with students	% limited/ specialized clusters 2-1 to 2-5	% diverse-use clusters 2-6 to 2-10	% distribution of all middle school teachers
English	(290)	15	22	18	19
Science	(314)	18	17	21	18
Math	(268)	29	20	4	21
Social Studies	(177)	16	11	13	13
Foreign Language	(22)	3	3	1	3
Mixed Academic Sec.	(190)	7	14	24	13
Computers	(86)	0	5	11	4
Business	(21)	0	2	1	1
Vocational	(39)	2	2	4	2
Fine Arts	(62)	7	4	1	4
Other Applied Sec.	(42)	3	2	2	2
All M.S. teachers	(1,511)	100	100	100	100

Universe: All middle school teachers in probability and purposive samples.

TABLE A-2: HIGH SCHOOL SOFTWARE USE CLUSTER GROUPINGS BY SUBJECT TAUGHT

Subject Taught	(N)	% do not use computers with students	% limited/specialized clusters 3-1 to 3-5	% diverse-use clusters 3-6 to 3-10	Total
English	(270)	28	63	9	100
Science	(291)	38	50	12	100
Math	(246)	49	46	5	100
Social Studies	(172)	41	51	9	100
Foreign Language	(57)	63	37	0	100
Mixed Academic Sec.	(53)	6	60	33	100
Computers	(89)	0	22	78	100
Business	(83)	8	41	51	100
Vocational	(70)	14	77	9	100
Fine Arts	(58)	34	58	8	100
Other Applied Sec.	(46)	51	37	12	100
All H.S. teachers	(1,435)	35	50	15	100

Universe: All high school teachers in probability and purposive samples.

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TABLE A-3: DISTRIBUTION OF SUBJECT AREAS
FOR SELECTED HIGH SCHOOL SOFTWARE USE CLUSTERS

Cluster	3-2	3-3	3-4	3-5	3-6	3-7	3-8	3-9	3-10	All H.S.
Main applications used in that cluster	Elem. Pattern	Graphics	Web	Word proc. with info	Com-puter lit	Internet	High use info-com-muniate	High use computer apps in classroom	High use computer skills in lab	
Subject Taught	Cluster Make-up: % of Teachers from Each Subject Area									
English	2	14	15	42	2	26	27	3	0	17
Science	11	7	32	20	20	15	20	16	11	22
Math	59	0	15	2	12	6	2	5	0	19
Social Studies	1	0	16	12	2	15	17	3	7	12
Foreign Language	5	0	3	4	0	0	0	0	0	5
Mixed Academic Sec.	1	11	2	5	5	13	7	5	4	3
Computers	4	4	2	3	26	9	17	30	56	5
Business	2	11	3	7	27	9	0	27	19	5
Vocational	9	28	7	2	3	2	2	0	4	4
Fine Arts	4	23	6	0	0	6	5	0	0	4
Other Applied Sec.	2	4	0	3	4	0	2	11	0	4
All H.S. teachers	100	100	100	100	100	100	100	100	100	100
(N)	(70)	(55)	(69)	(220)	(107)	(57)	(59)	(45)	(37)	(1,435)

Universe: All high school teachers in probability and purposive samples.

TABLE A-4: DISTRIBUTION OF TEACHERS ACCORDING TO TYPE OF STUDENTS' SOFTWARE USE AND FREQUENCY OF EACH STUDENT'S EXPERIENCE DURING CLASS, BY SUBJECT TAUGHT

Subject and Level Taught	(N)	% non-users	% limited software use	% specialized and not frequent	% diverse use but not frequent	% specialized & frequent use	% diverse and frequent use	Total
Elementary Self-Contained	(784)	13	30	8	17	8	25	100
Elementary Other	(291)	22	30	10	14	4	20	100
English	(560)	27	30	18	3	14	8	100
Science	(605)	36	30	10	10	8	6	100
Math	(514)	47	38	7	2	3	3	100
Social Studies	(349)	40	29	12	10	4	5	100
Foreign Language	(79)	55	30	13	2	0	0	100
Mixed Academic Sec.	(243)	15	23	13	12	19	19	100
Computers	(175)	1	16	2	9	19	53	100
Business	(104)	7	12	8	11	28	35	100
Vocational	(109)	20	37	8	7	22	7	100
Fine Arts	(120)	43	34	9	5	7	2	100
Other Applied Sec.	(88)	47	27	6	11	5	5	100
All teachers	(4,021)	30	30	10	9	9	12	100

Universe: All teachers in probability and purposive samples.

TABLE A-5. PERCENT OF COMPUTER-ASSIGNING TEACHERS WHO REPORT THAT THE FOLLOWING ARE AMONG THEIR *MOST IMPORTANT* OBJECTIVES FOR STUDENT COMPUTER USE

Subject and Level Taught	Find out info	Writing	Reinforce-ment	Computer skills	Analyze info	Reme-diation	Collabo-ration	Indepen-dent work	Presen-tation	Commu-nication
Elem. Self-Contained	54%	57%	37%	44%	15%	31%	27%	17%	9%	5%
Elem. Other	56	45	46	35	20	40	14	21	13	7
English	54	81	17	17	23	20	23	19	29	8
Science	60	36	34	25	46	18	20	14	23	9
Math	22	13	62	22	34	51	26	32	13	2
Social Studies	69	35	20	31	31	13	35	21	25	10
Foreign Language	39	38	37	16	34	35	2	43	17	2
Misc. Academic Sec.	73	54	20	30	23	11	20	20	18	23
Computers	26	7	44	59	39	13	29	33	14	18
Business	7	26	82	52	23	21	20	45	9	11
Vocational	52	14	38	31	32	11	30	46	12	7
Fine Arts	50	18	37	21	17	7	21	34	36	13
Other Applied Sec.	55%	30%	44%	14%	40%	19%	39%	20%	34%	0%

Universe: Probability sample; teachers who use computers with students in their selected class. For N's, see Table 6.

Note. About 1/4 of vocational and 1/2 of fine arts teachers also included an "other" objective among their top 3. Fewer than 10% of teachers of other subjects indicated that as well.

TABLE A-6: STUDENT PARTICIPATION IN USING COMPUTERS FOR CLASS OUTSIDE OF CLASS TIME (HOME + SCHOOL) BY WHETHER TEACHER REPORTED SPECIFIC TYPES OF SOFTWARE USED IN TEN OR MORE LESSONS

	Use of computers outside of class for class work (scale1-5)*				
Type of Software	Teachers reporting software used in 10+ lessons (N)		Other computer-assigning teachers (N)		Effect Size
Presentation s.w.	3.21	(138)	2.61	(1,207)	0.51
Word Proc.	2.96	(673)	2.39	(683)	0.48
E-mail	3.18	(103)	2.64	(1,253)	0.46
Multimedia	3.16	(109)	2.64	(1,247)	0.44
CD-ROM Reference	3.05	(301)	2.57	(1,056)	0.41
Graphics oriented	2.95	(179)	2.62	(1,176)	0.28
WWW Browser	3.01	(318)	2.58	(1,045)	0.16
Spreadsheet/Database	2.82	(138)	2.65	(1,220)	0.14
Simulation/Exploratory	2.68	(159)	2.65	(1,171)	0.03
Skill Games	2.34	(251)	2.71	(1,106)	-0.31

Universe: Probability sample; teachers who used computers with students in selected class, questionnaire versions 1 & 2.
Score is average of the two measures: out-of-class at-school computer use and out-of-school computer use, where 1 = 'none or few students' 2 = '1/4 of students' 3 = '1/2 of students', 4 = '3/4 of students' and 5 = 'all students.' (Overall mean, 2.51, overall standard deviation 1.16.)

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TABLE A-7: PERCENT OF WEEKLY COMPUTER-ASSIGNING TEACHERS AND NON-ASSIGNING TEACHERS WHO USE COMPUTERS WEEKLY FOR EACH PROFESSIONAL ACTIVITY SHOWN

		Type of Professional Use							
Computer Use	(N)	Make handouts	Record or calculate grades	Write lesson plans or notes	Info or pictures from Internet for lessons	Corres-pond with parents	Camcorder/ digital cameras, scanners	Exchange files with other teachers	Post student work on the web
All teachers	(2,178)	66	50	42	28	23	7	7	5
Professionally only	(411)	69	60	43	27	24	4	7	4
Weekly with students	(677)	77	51	51	37	29	11	9	9
Standardized difference (effect size)		.16	-.18	.16	.23	.11	.27	.07	.24

Universe: Probability sample only. Teachers intermediate in assigning computer work to students are not shown.
"All teachers" includes teachers who use computers occasionally with students, who are not shown separately.
Largest differences are highlighted.

TABLE A-8: MEAN BREADTH AND FREQUENCY OF STUDENT SOFTWARE USE (SCALE SCORE) FOR TEACHERS HAVING SPECIFIC COMPUTER SKILLS THEMSELVES, BY SUBJECT-LEVEL

Subject and Level Taught	Display the directory of a disk	Copy files from one disk to another	Create a new database and establish fields and screen layouts	Imbed graphics into a word-processor document	Prepare a slide show using present-ation software	Use a WWW search engine	Develop multimedia document using Hyperstudio or similar authoring software	All teachers in that subject
Elem. Self-Cont.	2.09	2.20	2.55	2.46	2.85	2.25	3.03	1.88
Elementary Other	1.95	2.08	2.20	2.18	2.64	1.93	2.48	1.72
English	1.44	1.52	1.85	1.73	2.18	1.51	2.22	1.27
Science	1.24	1.24	1.41	1.50	1.77	1.32	1.86	1.16
Math	0.74	0.75	0.91	0.92	1.07	0.84	1.28	0.67
Social Studies	1.40	1.46	1.42	1.74	1.75	1.31	2.31	1.16
Foreign Language	0.60	0.71	0.85	0.51	1.08	0.63	1.00	0.63
Mixed Academic Sec.	2.15	2.22	2.44	2.54	2.77	2.24	3.05	1.93
Computer	3.16	3.18	3.34	3.22	3.43	3.17	3.68	3.14
Business	2.23	2.26	2.54	2.34	2.89	2.47	2.97	2.21
Vocational	1.30	1.44	1.48	1.48	1.53	1.32	1.52	1.36
Fine Arts	0.90	0.88	1.01	1.04	1.35	1.09	1.55	0.87
Other Applied Sec.	1.12	1.42	1.26	1.40	1.41	1.09	2.50	1.01
All teachers	1.48	1.54	1.75	1.77	2.02	1.55	2.30	1.36

Universe: All teachers in probability and purposive samples. For N's see Table A-4.
Comparing across rows, shaded cells highlight those computer skills on which teachers of that subject score higher.

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TABLE A-9: TEACHER COMPUTER SKILLS AND EXPERTISE BY OBJECTIVES FOR COMPUTER USE

	Among Teachers Selecting This Objective As One of Their 3 Most Important									
% claiming the specific computer skills below:	Find out about ideas and info	Express self in writing	Master-ing skills	Improve com-puter skills	Analyze info	Reme-diation	Learn to work collabo-ratively	Learn to work indepen-dently	Present info to an audience	Commun-icate electro-nically
Use a WWW search engine	76	69	63	69	79	56	74	69	76	88
Develop a multimedia document using Hyperstudio or similar authoring software	28	25	24	26	32	12	36	28	43	33
Imbed graphics into a word-processor document	57	56	57	58	63	45	59	58	67	68
Prepare a slide show using presentation software	34	30	36	35	46	25	42	37	47	42
Create a new database and establish fields and screen layouts	46	44	48	51	55	35	49	48	48	54
Copy files from one disk to another	82	80	75	78	85	67	82	77	85	86
Display directory of a disk	81	80	79	82	83	72	82	75	85	87
(N)	(1,436)	(1,210)	(785)	(800)	(772)	(517)	(655)	(556)	(632)	(242)
% very experienced in 2+ platforms or expert in 1+ platforms	34	33	34	31	38	27	34	29	38	45
(N)	(1,475)	(1,237)	(802)	(814)	(783)	(535)	(667)	(577)	(637)	(249)

Universe: Probability and purposive samples; teachers who use computers with their selected class.

TABLE A-10: PERCENT OF TEACHERS REPORTING VARIOUS OBJECTIVES FOR STUDENT COMPUTER USE AMONG TEACHERS VERY EXPERIENCED OR EXPERT ON AT LEAST ONE PLATFORM, BY TEACHER'S PLATFORM OF EXPERTISE (MACINTOSH OR WINDOWS)*

	Percent Of Teachers (those very experienced or expert on at least one platform) Naming Each Objective		
	All subjects	English only	Comp-Bus Only
Mastering skills (reinforcement)			
Macintosh	28	6	42
Windows	39	24	63
Difference	-11	-19	-21
Remediation			
Macintosh	16	8	8
Windows	18	21	11
Difference	-2	-13	-3
Express oneself in writing			
Macintosh	48	83	18
Windows	41	83	19
Difference	6	1	-1
Communicate electronically			
Macintosh	11	15	17
Windows	10	15	9
Difference	1	0	8
Find out about ideas and information			
Macintosh	56	61	32
Windows	48	47	25
Difference	8	14	7
Analyze information			
Macintosh	32	17	22
Windows	32	22	29
Difference	0	-5	-7
Present information to an audience			
Macintosh	28	38	26
Windows	20	24	12
Difference	9	14	14
Improve computer Skills			
Macintosh	26	20	44
Windows	33	18	49
Difference	-7	2	-5
Learn to work collaboratively			
Macintosh	27	29	33
Windows	25	13	24
Difference	2	16	9
Learn to work independently			
Macintosh	17	19	33
Windows	25	29	43
Difference	-7	-10	-10
(N) Macintosh	(1,188)	(191)	(119)
(N) Windows	(1,032)	(124)	(217)

Universe: Both probability and purposive samples.
*Teachers giving self-ratings of "very experienced" or "expert" on platform involved.

APPENDIX B. SUMMARY OF STUDY METHODOLOGY

The Teaching, Learning, and Computing (TLC) study is comprised of completed questionnaire responses from teachers, principals, and school technology coordinators from three separate samples of schools. Somewhat more than one-half of the 1,616 schools sampled for the study (56%) were a stratified national probability sample of elementary (299 schools), middle (253), and high schools (346), including 83 private and parochial schools. Those schools were sampled with probabilities related to both size (estimated number of full-time teachers, grades 4 to 12) and the presence of computer technology (based on an index developed for Quality Education Data, Inc.). The sampling universe was the approximately 108,000 schools in the Quality Education Data (QED) database.

The remaining samples of schools are referred to as "purposive samples" and were based on compiling, refining, and sampling from lists of two basic types of schools: "High-end Technology schools" are schools with substantial amounts of computer technology per capita, including schools selected from the QED technology presence index and schools identified through books, articles in magazines and school web-sites. "Reform Program schools" were compiled by identifying schools or individual teachers who had been long-term (3 year+) participants in one of 54 different national or regional externally-defined "programs" of major school or instructional reform.

In all three school samples, teachers were sampled from grades 4-12 and from all subjects except physical education and special education. At each sampled school, three to five teachers (3, elementary; 5, middle and high school) were selected with probabilities related to the teacher's reputed instructional practices and use of technology. A small number of teachers (a maximum of 2 per school) were selected with certainty (probability equal to 1) based on the principal's attribution of that teacher having an exemplary instructional practice or based on their known participation in the selected program of instructional reform. Because unequal probabilities were used, at both school and teacher level, all analysis employs weighted data with weights inverse to the probability of selection, as modified by stratum-specific non-response rates and within-school partial completions of teacher rosters.

The research began in the Spring of 1997 with a validation study of self-report measures of teacher beliefs and practices and exploratory studies of survey measures of changes in teaching practices and technology use and school-level investments in technology hardware, software, and training and teacher support. The validation study provided self-report data from 72 teachers in 24 schools and detailed classroom observation and interview data with those same teachers. At the school level, pilot versions of surveys were used in order to test measurement approaches for studying technology expenditure information, hardware and software acquisition, and investments of time and money in teacher training and support activities.

The data collection itself was the second stage of the project, taking place from January through June of 1998, and conducted by the Battelle Centers for Evaluation and Health Research. Data collection encompassed an initial district contact information letter, followed by a school mailing, in which teachers were rostered and sampled; a subsequent mailing of questionnaires for teachers, the school-level technology coordinator, and the principal; and several waves of mail and telephone follow-up, editing, coding, data entry, and data cleaning. The teacher respondents were asked to complete a survey booklet about their teaching practice and teaching beliefs that was 21 pages in length and required approximately 60-75 minutes. Four different versions of the teacher survey booklet were used, with overlapping sets of questions. These are called questionnaire versions 1, 2, 3, and 4. The school technology coordinator's booklet was approximately the same length as the teacher survey and principally concerned the investments their school has made in computer hardware, software, and teacher training and support, measured both financially and in units of time, materials, and equipment.

The principal's survey booklet was half as long, and inquired about technology-related school policies and efforts in school restructuring and reform.

The third stage of the project involves data analysis, preparation of reports, and the release of national data files for secondary analysis.

PARTICIPATING SCHOOLS

Across the three samples, 1,215 of the 1,616 schools selected for participation agreed to participate in the study (75%). They did so by returning a roster of a specifically requested number of teachers (10 in elementary schools; 15 in middle and high schools), providing rough estimates of each teacher's use of computers, projects, and emphasis on critical thinking and complex problem-solving. The attained probability sample (rostered schools) consists of 598 public and 57 private and parochial schools.

The High-end Technology sample includes 182 rostered schools including 86 entering the sample based on having among the highest technology presence index scores in the QED database. The remainder were believed to have substantial computer and Internet technology, as identified through publicly available information from school Web sites, books, and magazine articles.

The Reform Program sample includes 378 rostered schools that were identified through various sources as being involved in one of 53 different reform efforts. The "reform program" and "high-end technology" samples involve some definitional overlap in that 13 of the reform programs (with 90 rostered schools) appear to have substantial amounts of technology, while 72 rostered high-end technology schools appear to have explicit instructional reform emphases even though they did not participate in any of the major reform programs selected. A majority of Reform Program schools are involved in a school-wide reform program (e.g., Coalition of Essential Schools, League of Professional Schools, Bay Area School Reform Collaborative, Co-NECT Schools) These total 30 separate programs (200 schools) including four with a technology emphasis and five that are not 'programs' per se but schools linked by a common origin (e.g., 'Charter Schools with a constructivist flavor'). In addition, there are four programs that are limited to math and/or science (26 schools), 17 programs that enrolled individual teacher participants (nine of these are technology-centered), and two programs that recognized individual exemplary teachers.

Lists of participating schools or teachers were obtained directly from the programs in 44 of the cases; in the other 9 they were obtained from public sources--lists of participants on World Wide Web sites or in books. (In some cases, these were not actually programs--just schools identified as exemplary in the public source.) Forty programs provided more schools than were needed so that probability sampling was employed to select the particular schools that would be incorporated into the study. (In some cases, additional selection criteria were used prior to the sampling.)

SELECTION OF TEACHERS

At each of the 1,616 studied schools, samples of 3 (elementary) or 5 (middle and high school) teachers were drawn through probability sampling methods. A Teacher Roster form was sent to the school principal as the first major mailing to the school (following an introductory letter). That form asked the principal to roster either 10 (elementary) or 15 (secondary) teachers of grade 4 or higher (in some cases limited to the same subject taught by a reform program-participating teacher), starting with teachers with last names beginning with a randomly selected letter of the alphabet and proceeding alphabetically. The roster form asked for 4 additional pieces of information about the rostered teachers

that were used to assign sampling weights to each rostered teacher (e.g., subject taught, use of computers, use of projects in teaching).

In addition, two other sources of teachers are incorporated as purposive samples. Approximately 250 teachers were individually selected from the purposive school samples based on reports (public or program-supplied) of their participation in educational reform activities. And finally, approximately 800 teachers were chosen through nominations by principals (as part of the Roster form) as exemplary practitioners of constructivist approaches to teaching.

ATTAINED SAMPLE

Response rates of individually selected teachers, principals, and technology coordinators averaged about 70%. Altogether, responses were obtained from 4,083 teachers of grade 4 and higher in 1,150 schools, as well as 845 technology coordinators and 867 school principals.